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RESUMO

Actualmente são reconhecidas 88 espécies de cetáceos em todo o mundo, entre 14 espécies da subordem Mysticeti (baleias de barbas) e 74 da subordem Odontoceti (golfinhos e cachalotes). Estes são animais com uma biologia e ecologia complexas e particulares, tendo necessidades de habitat específicas que influenciam a sua distribuição. Contribuem para isso as componentes oceanográficas (profundidade, topografia, ventos e correntes) que influenciam, por sua vez, a produtividade primária e, logo, a disponibilidade de alimento para os cetáceos. Outros factores como a fisiologia, capacidades auditivas, tipo de alimentação, estratégias reprodutivas e padrões de migração dos cetáceos são também determinantes para a definição do seu habitat.

Por outro lado, com o aumento da densidade e dispersão da população humana, o ambiente natural sofre uma pressão cada vez mais forte, nomeadamente ao nível dos oceanos. Consequentemente, os cetáceos sofrem também o impacto mais ou menos directo de diversas actividades humanas, entre as quais se contam a caça directa, as pescas e a navegação (devido a colisões com embarcações), bem como as actividades que libertam contaminantes, produzem ruído ou contribuem para as alterações climáticas.

Neste trabalho foi efectuada uma revisão bibliográfica das necessidades de habitat das espécies de cetáceos do Nordeste Atlântico, bem como um levantamento das actividades humanas para as quais já se registou uma afectação negativa destas espécies. Estes dados foram compilados em matrizes de presença/ausência, tendo sido agrupados em diferentes categorias às quais foram atribuídos códigos. Procedeu-se a uma análise descritiva dos dados, identificando-se graficamente o número de espécies em cada categoria. Os dados foram ainda tratados de forma a identificar grupos de espécies com as mesmas preferências de habitat e afectadas pelas mesmas actividades, através de Análises de Correspondências e Classificação. Foi ainda realizada uma compilação dos principais objectivos de conservação dos actuais instrumentos legais e acordos, bem como das espécies aos quais estes se referem.

A análise descritiva das necessidades de habitat evidenciou a ocorrência preferencial dos cetáceos por viver a profundidades entre 200-2000 m em águas subtropicais/tropicais, reproduzir-se na Primavera e Verão, efectuar migrações de

curta distância, viver solitários ou em pequenos grupos (até 12 indivíduos) e alimentar-se de pequenos peixes e cefalópodes na zona pelágica, perseguindo activamente as suas presas. A análise de correspondências das preferências de habitat demonstrou uma distinção clara entre misticetos e odontocetos, essencialmente no que respeita às preferências de alimentação (métodos e presas), tamanho dos grupos sociais, reprodução e migração. Foram também identificadas duas tendências entre os odontocetos, embora de uma forma menos clara, sendo diferenciadas pelo tamanho dos grupos sociais que formam e pelo método utilizado para capturar as suas presas. A análise classificativa permitiu igualmente distinguir misticetos de odontocetos, embora não tivesse permitido identificar os dois grupos correspondentes às tendências observadas anteriormente.

A análise descritiva das actividades humanas permitiu verificar que o ruído provocado pela prospecção geofísica, a captura colateral (*by-catch*) na pesca do atum e em redes de emalhar e de arrasto, as colisões com navios e a mortalidade directa são as actividades que afectam mais cetáceos no Nordeste Atlântico. A análise de correspondências revelou, mais uma vez, uma clara distinção entre misticetos (essencialmente afectados pelo ruído de navios e pela mortalidade directa) e odontocetos. Entre os últimos foi possível discernir duas tendências: uma envolvendo baleias de bico e cachalotes (perturbados pelo ruído devido à prospecção geofísica e às actividades militares) e outra incluindo os golfinhos (principalmente afectados pela captura colateral – *by-catch*, pela indústria de observação – *whale-watching* – e pela colisão com navios).

Devido ao elevado impacto das actividades humanas sobre os ecossistemas marinhos, particularmente nos cetáceos, têm sido estabelecidos diversos acordos e documentos legislativos, ao nível internacional, Europeu, regional e local, no sentido de promover a redução, o controlo e a monitorização desses impactos, bem como a protecção e conservação das espécies. Estas ferramentas têm sido adoptadas por um número crescente de países à medida que aumenta a consciencialização nesta área. Na sua maioria, estes documentos referem-se à restrição da captura directa (propositada ou acidental) ou à regulamentação de actividades que afectam mais indirectamente os cetáceos, salientando, ao mesmo tempo, a necessidade de proteger os habitats e ecossistemas.

Tais instrumentos incluem, por exemplo:

- A Convenção Internacional para a Regulação da Actividade Baleeira (1946) e a actividade da Comissão Baleeira Internacional (CBI, 2009);

- A Convenção sobre o Comércio Internacional das Espécies de Fauna e Flora Selvagens Ameaçadas de Extinção (Convenção de Washington, CITES, 1979);
- A Convenção Relativa à Conservação da Vida Selvagem e dos «Habitats» Naturais da Europa (Convenção de Berna, 1979);
- A Convenção sobre a Conservação das Espécie Migradoras Pertencentes à Fauna Selvagem (Convenção de Bona, CMS, 1982);
- O ASCOBANS ("Agreement on the Conservation of Small Cetaceans of the Baltic, North-East Atlantic, Irish and North Seas", 1992);
- A Directiva Habitats da Comunidade Europeia (1992);
- A Convenção para a Protecção do Ambiente Marinho do Nordeste Atlântico (OSPAR, 1992);
- O ACCOBAMS ("Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area", 1996).
- A Lista Vermelha da IUCN (2008);

Todas as espécies de cetáceos do Nordeste Atlântico se encontram abrangidas por, pelo menos, sete destes instrumentos, estando ao abrigo das suas disposições. Estas parecem no entanto ser demasiado gerais, sendo importante que sejam definidas medidas e restrições cada vez mais explícitas e aplicadas globalmente.

Os esforços conservacionistas têm permitido o desenvolvimento da actividade de observação de cetáceos, como alternativa à extracção, como na actividade baleeira. No entanto, a expansão desta indústria tem sido feita de uma forma algo descontrolada, sem que se proceda a uma correcta avaliação dos seus impactos sobre as comunidades marinhas, em especial as espécies alvo. Neste sentido, o *International Fund for Animal Welfare* (IFAW) tem duplicado esforços para promover uma actividade de observação de cetáceos (*whale-watching*) responsável, nomeadamente por parte de países com forte tradição baleeira, cooperando simultaneamente com a Comissão Baleeira Internacional (CBI).

Na recente 61ª Reunião Anual da CBI (Madeira, Portugal, 2009) foi abordado o tema da observação de cetáceos, tendo sido uma vez mais salientada a importância de uma gestão cuidadosa desta indústria com especial atenção para os seus efeitos negativos sobre as espécies. Nessa mesma reunião foram ainda abordadas as questões da caça costeira de pequena escala que o Japão pretende efectuar, das licenças especiais e dos santuários, questões centrais na discussão do futuro da CBI. As decisões relativas a estes temas foram, no entanto, adiadas até à próxima

Reunião Anual, em Marrocos. Outro tema controverso abordado nesta reunião foi o dos potenciais efeitos negativos das alterações climáticas nos cetáceos, assunto sobre o qual muito se tem especulado mas pouco se tem analisado e comprovado. A CBI reforçou aqui também a sua preocupação com este assunto, em particular relativamente a espécies com pequenas populações ou limitada dispersão, que já estejam a sofrer outro tipo de impactos humanos ou que se distribuam em áreas sujeitas a alterações climáticas rápidas. Foi assim adoptada uma resolução visando a necessidade de colaboração e cooperação dos governos no sentido de considerarem o efeito das alterações climáticas no âmbito dos planos de conservação já existentes, agindo urgentemente para reduzir a rapidez e extensão desse fenómeno.

Contudo, apesar do progresso na conservação dos cetáceos, a maioria dos objectivos e medidas de conservação focam-se maioritariamente na acção directa do homem. Desta forma, os impactos indirectos mantêm-se grandemente ignorados, faltando informação e investigação de base relativamente às características ecológicas dos cetáceos e aos efeitos secundários das diversas actividades humanas. Para o correcto desenvolvimento de planos de conservação eficazes, é crucial promover a cooperação e partilha de informação entre os governos e as diversas entidades dedicadas à conservação da biodiversidade, incluindo informações provenientes, por exemplo, das indústrias dos transportes marítimos, das pescas, da observação de cetáceos e da produção de energia ao largo (*offshore*). É ainda essencial desenvolver estudos relativamente a efeitos indirectos do desenvolvimento humano, como o ruído e a poluição, aplicando na prática, acima de tudo, o Princípio da Precaução.

Palavras-chave: Ecologia; Mysticeti; Odontoceti; Pressões humanas; Instrumentos Conservacionistas; Cooperação Internacional.

SUMMARY

Cetaceans are very complex in their biology and ecology, having particular habitat needs that influence their global and local distribution, such as oceanographic features and prey availability. Knowledge on specific habitat needs (essential environmental characteristics for the animals' survival) is of major importance for the definition of effective conservation goals and management measures. These species are vulnerable to pressures from human activities, for instance from whaling, fisheries and navigation, as well as those releasing contaminants or generating oceanic noise. The available information on cetacean habitat preferences and registered human activities' impacts was compiled for North-East Atlantic cetaceans, from primary and secondary references, as presence/absence data matrices. These were analysed descriptively and through Correspondence and Classification Analyses. The habitat needs analyses produced a clear distinction between mysticetes (baleen whales) and odontocetes (toothed whales), and, in a less obvious way, two trends in the dispersion of the odontocetes. The characteristics influencing these distinctions were mainly related to feeding preferences, typical group size, reproductive seasonality and migratory patterns. Similarly, the human activities analysis showed the distinction between mysticetes and odontocetes, and among these, between beaked and sperm whales, and dolphins. Mysticetes were found to be mainly affected by whaling and noise from shipping; beaked and sperm whales by noise from seismic surveys and military activities; and dolphins by by-catch, whale-watching and collisions with ships. Given the increase of human impacts on marine ecosystems, several international, European, regional and local agreements and legislation have been agreed. In general, these aim to reduce and monitor human pressures on biodiversity, and they particularly promote the protection and conservation of cetaceans. Nevertheless, many of these instruments concern only the direct effects, while the indirect ones have been largely overlooked, due to the lack of reliable information from scientific research on both cetacean ecology and the secondary effects of many human activities. In addition, reduced cooperation between the various entities and governments is also a major difficulty. This study aimed to contribute with information on this subject and in the awareness of the urgency of the protection of these charismatic animals.

Keywords: Ecology; Mysticeti; Odontoceti; Anthropogenic pressures; Conservation instruments; International cooperation.

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1. INTRODUCTION

1.1. Cetaceans

Currently, there are 88 accepted species of cetaceans in the world, 14 belonging to the suborder Mysticeti (4 families, baleen whales) and 74 to the suborder Odontoceti (8 families, toothed whales) (ITIS, 2009). These species are very complex in terms of their ecology, social structure and behaviour (Cañadas and Hammond, 2008), are exclusively aquatic (feeding, travelling, resting and reproducing in the water) and inhabit different types of aquatic systems, from rivers to the open ocean, and from polar to tropical regions (Jefferson *et al.*, 1993; Waller *et al.*, 1996; Forcada, 2009;). The main distinction between the two cetacean suborders relates to their feeding: mysticetes have large baleen plates suspended from the upper jaw, with which they filter their prey, while odontocetes have teeth, pursuing and taking individual prey (Jefferson *et al.*, 1993).

As with many other organisms, cetaceans are affected by human activities developed both offshore and inland, which may cause physical harm or behavioural changes. Nevertheless, many of these interactions are poorly known and records are frequently anecdotal due to the lack of comprehensive studies. Different legislation and agreements have been developed to protect cetaceans (among other animals), by either regulating or prohibiting activities or actions that threaten them, their prey or the areas in which they live.

Defining guilds or types of organisms is an increasing way of categorizing animals (e.g. Elliott *et al.*, 2007). Hence, if the habitat needs of different cetaceans can be objectively described, allowing the identification of guilds based on the similarities between species, the effects of human activities on some of the species can be assumed for the others, for which there is a lack of information. This is important for the identification of particular habitats and areas at risk, where human activities should be regulated.

Although cetacean species from the North-East Atlantic area will be of special concern in this work, in this introduction other global issues will be mentioned.

1.2. Aims and Objectives

The aim of this study is to analyse cetaceans' habitat needs and the impact of human activities on them, relating these to present conservation goals.

Therefore, the objectives of this study include:

- To compile information on cetaceans' habitat needs;
- To compile information on human activities negatively affecting cetaceans;
- To compile information on conservation instruments referring to cetaceans;
- To analyse the similarities between cetacean species with respect to their habitat needs and their perturbation by human activities;
- To examine the implications of human activities affecting cetaceans in the context of the present management and conservation instruments.

1.3. Cetaceans' Habitat Needs

As with all organisms, cetaceans have characteristic habitat needs, which influence their geographic dispersal. Small-scale distributions are essentially influenced by intrinsic factors, such as the animals' physiology, behaviour and ecology (Bowen and Siniff, 1999), reproductive status, feeding strategies and inter-specific relationships (Cañadas and Hammond, 2008). In turn, large-scale habitat preference and selection depends on major oceanographic features (Baker, 1978; Jefferson *et al.*, 1993; Waring *et al.*, 2009). The complex and dynamic interaction between depth, bottom topography and winds generates surface ocean currents, which promote upwelling and indrift movements that bring nutrients to the surface, increasing primary productivity. This high primary productivity leads to an increase of prey availability for cetaceans, inducing their high concentration in such fertile areas (Jefferson *et al.*, 1993; Trujillo and Thurman, 2005).

All these features are then selected by cetaceans in order to fulfil their basic ecological requirements, such as the availability of prey; the opportunity for mating and calving; the avoidance of predators/competitors and the ability to move between habitat patches (Baker, 1978; Jefferson *et al.*, 1993; Azzellino *et al.*, 2008). Nevertheless, cetaceans' physiological capacities and characteristics are also important to fulfilling these requirements, such as their auditory and echolocation capabilities, feeding habits, reproductive strategies and migratory patterns.

Cetaceans' feeding habits are extremely significant for their distribution, not only relating to the type of prey they consume but also to the capture method they use (filtering or actively hunting individual prey) (Jonsgård, 1966; Baker, 1978; Waring *et al.*, 2009). The type of prey consumed mainly leads plankton feeding mysticetes to depend much more on highly productive upwelling areas, whereas pelagic prey feeding odontocetes and Bryde's whales (*Balaenoptera brydei*) can find food, not only within the most fertile areas, but also along the succession and migration paths of their prey. Although many cetaceans are usually seen alone, in pairs or in small groups (e.g. Cuvier's beaked whale (*Ziphius cavirostris*), and pygmy and dwarf sperm whales (*Kogia breviceps* and *Kogia sima* respectively)), some of them tend to aggregate in larger groups in feeding areas where food is abundant (e.g. minke whales (*Balaenoptera acutorostrata*), belugas (*Delphinapterus leucas*) and harbour porpoises (*Phocoena phocoena*)), subsequently scattering when and where food becomes more limited (Baker, 1978; Jefferson *et al.*, 1993; Evans and Stirling, 2001; Reeves *et al.*, 2002).

Mature animals of some species also aggregate when on breeding grounds (e.g. blue whales (*Balaenoptera musculus*) and belugas) (Baker, 1978; Jefferson *et al.*, 1993), Additionally, bowhead (*Balaena mysticetus*) and minke whales' calves frequently aggregate off the coast of Norway (Baker, 1978), while humpback whales (*Megaptera novaeangliae*) are known to have feeding grounds in the same area (Jonsgård, 1966; Christensen *et al.*, 1992; Carwardine *et al.*, 1998).

The cetaceans' reproductive strategies involve long gestation times, low reproductive rates, intensive maternal care, relatively low growth rates and life spans between 11 and 90 years (Evans, 1993; Waller *et al.*, 1996; Evans and Stirling, 2001). There are cetaceans breeding at all latitudes and in all seasons, but different species frequently have preferential areas and periods for reproduction.

In their pursuit for more suitable habitats for feeding and breeding throughout the year, the majority of cetaceans undergo seasonal migrations, where the distance varies greatly between species. The classic long-range migrations are those of many baleen whales, which spend the summer feeding on polar highly productive areas, and the winter reproducing in tropical regions (Jonsgård, 1966; Baker, 1978; Christensen *et al.*, 1992; Bérubé *et al.*, 1998; Stern, 2002; Waring *et al.*, 2009). However, while some species repeatedly follow this pattern, others are much more irregular (for which the frequency and range of migration depends on the seasonal variations of their main prey), and some move only with the retreat and advance of the Arctic pack-ice (Jonsgård, 1966; Baker, 1978; Christensen *et al.*, 1992; Evans, 1993; Bérubé *et al.*, 1998; Hindell, 2002; Stern, 2002; Waring *et al.*, 2009). During feeding migration, some species may experience population segregation, with females and calves remaining in coastal areas and males in the open sea (e.g. minke whales) (Jonsgård, 1966; Ichii and Kato, 1991) In contrast, amongst odontocetes only sperm whales' males (*Physeter macrocephalus*) make long-range migrations to higher latitude grounds, immediately after the breeding season, whereas females, calves and immature males stay on sub-tropical/tropical breeding areas throughout the year (Christensen *et al.*, 1992; Jefferson *et al.*, 1993; Waller *et al.*, 1996; Bowen and Siniff, 1999; Evans, 2002). Other odontocetes have only small scale latitudinal or onshore to offshore movements, pursuing the seasonal succession and migration of their main prey species (fish and cephalopods). In particular, belugas and narwhals (*Monodon monoceros*) only move with the retreat and advance of the polar ice, such as bowhead whales (Baker, 1978; Jefferson *et al.*, 1993; Macdonald and Barrett, 1993; Waller *et al.*, 1996).

Cetaceans have highly sensitive auditory systems, most of them are highly vocal and many also exhibit a greatly developed echolocation capacity. All these attributes are essential to communicate with other individuals (possibly over hundreds of kilometres) and to recognize their surrounding environment, allowing them to navigate, avoid obstacles and predators, forage for food and find other individuals (Richardson *et al.*, 1995; Gordon and Tyack, 2001). Mysticetes and odontocetes have distinct auditory capacities: mysticetes are considered as low frequency sound producers and their low frequency moans, calls and songs have been suggested to be used for long-distance communication, since they can also hear well at infrasonic frequencies (Waller *et al.*, 1996; Wartzok and Ketten, 1999). Odontocetes are high frequency sound producers and are assumed to be true echolocators, both emitting and receiving ultrasonic sounds to image their environment (Waller *et al.*, 1996). The distinct auditory capacities between the two cetacean groups are directly related to their feeding methods too, with mysticetes using visual and passive acoustic cues to find their prey, while odontocetes hunt using their sight, hearing and active echolocation (Waller *et al.*, 1996).

1.4. Influence of Human Activities

The human population is increasing and its growing demand for natural resources and development has led to the intense exploitation of most marine areas (Halpern *et al.*, 2008). This usually affects marine organisms, and particularly cetaceans, for which the most impacting human activities, both directly and indirectly, are whaling, fisheries, physical and chemical contamination, vessel collisions, noise production and climate change (Waring *et al.*, 2009).

i. <u>Whaling</u>

Many aboriginal people have hunted, and still hunt, marine mammals for subsistence use. However, this is quite insignificant compared to the commercial whaling operations that started in the 10th century and culminated in the 20th century, causing most baleen and sperm whales' stocks to be regarded as over-exploited (Clapham and Baker, 2002; Waring *et al.*, 2009). Although the International Convention for the Protection of Whales was signed in 1946, North Atlantic commercial whaling only decreased when the moratorium came into effect in 1987 (Clapham and Baker, 2002; Waring *et al.*, 2009). Presently, subsistence hunting continues in the Faroe Islands, Greenland, Canada and Russia (fin (*Balaenoptera physalus*), minke and pilot whales (*Globicephala* spp.), harbour porpoises and belugas) and scientific whaling started in Norway and Japan (minke whales), while commercial exploitation still persists in Iceland (fin and minke whales) (Parsons *et al.*, 2007; Waring *et al.*, 2009).

Although whaling pressure has decreased for most species, the low growth and reproductive rates of most large whales, as well as the influence of other human interactions, are restricting North Atlantic stocks in their recovery, particularly the northern right whale (Parsons *et al.*, 2007; Waring *et al.*, 2009). For odontocete species it is not yet clear whether the populations can withstand the present removals, but it appears as though whaling is causing significant ecological changes, such as the reduction of top predators and of competitive interactions (Waring *et al.*, 2009).

ii. <u>Fisheries</u>

Fishing activities can affect cetaceans through operational (accidental capture and gear entanglement) and biological (alterations in prey availability) interactions.

Accidental captures (resulting in either immediate death or injuries that reduce the animals' survival probability) have already caused some local populations to become close to extinction, such as harbour porpoises, bottlenose dolphins (*Tursiops truncatus*) and belugas (Northridge, 2002). Some of the most reported fishing gear types in terms of cetacean by-catch are gillnets, purse seine nets and pelagic trawls (Fertl, 1997). However, driftnets, long lines and traps (e.g. lobster pot lines) have also caused cetacean accidental captures, especially among small cetaceans (Northridge, 1991; Northridge, 2002). On the other hand, for large cetaceans, only a few interactions with fisheries have been recorded, and this may be due to the type of fishing methods used or to the fact that whales use areas where fishing is less intense (Northridge, 1984). Gillnets seem to greatly affect harbour porpoises and common dolphins (*Delphinus delphis*), particularly monofilament and set gillnets (Northridge, 1991; Tregenza *et al.*, 1997; Parsons *et al.*, 2000b; Parsons *et al.*, 2007). Due to cetaceans' strong social structure, dense groups may forage near pelagic trawling operations, leading to clustered by-catches, particularly of midwater feeding species (Fertl, 1997). Bottom trawls are mainly responsible for sea floor destruction (affecting food webs) though they can also take some species (Plagányi and Butterworth, 2005). Purse seine nets are frequently used encircling dolphin schools which are often associated with tuna schools and, although some measures have been taken to reduce the number of dolphins accidentally captured, a few thousand still die every year in the operation of this type of gear (Northridge, 2002). Gear entanglement, discarded traps, tangle nets and pelagic gillnets are possibly mainly responsible for this interaction, due to their passive operation and large net size and numbers ("ghost fishing"). Bottom trawls, coastal gillnets, longlines and lures also give concern (Breen, 1990).

Cetaceans and fisheries interact by either competing for the same prey species, as is the case of fin, humpback and killer whales (*Orcinus orca*), or by taking different prey in cases when the removal of one prey affects positive or negatively the availability of the other prey species. Alternatively, fisheries often also physically change the habitats (e.g. trawls), thus changing the composition and abundance of the fish communities (for example, scavenger demersal fishes may dominate) and affecting cetaceans and other predators (Northridge, 2002; Parsons *et al.*, 2000b). The over-exploitation of some fish stocks (e.g. mackerel and herring) can lead to an increase in the abundance of other species. This may result in a change in the cetaceans' diet or cause some species to geographically change their distribution (Kenney *et al.*, 1996; Parsons *et al.*, 2007). Another potential effect is that the lack of prey may lead to increased blubber metabolism utilisation that frequently has high concentrations of pollutants (Parsons *et al.*, 2007). These pollutants, then released and assimilated by cetaceans' bodies, might result in immune system suppression and other detrimental physiological effects, possibly related to mass mortalities in some areas such as the Mediterranean Sea. Conversely, the decrease in the thickness of the subdermic blubber layer may cause difficulties in temperature maintenance.

iii. Contaminants

Cetaceans can be affected by three major types of pollution: marine debris and chemical and biological contaminants. Cetaceans can either get entangled in marine debris or ingest it. From entanglement in marine debris, cetaceans can suffocate (if they cannot emerge to the surface to breathe), starve, be predated (due to lack of mobility to escape), or suffer physical trauma, growth deformities and reduced blood circulation in some body parts (Parsons *et al.*, 2007). In addition, the ingestion of debris can result in physical damage or blockages to the digestive system, intoxication and a false feeling of satiation. Such effects can be generated by plastic bags and packages (in most cases), synthetic ropes and discarded fishing nets or fragments, as well as other non-plastic materials, essentially due to their resilience in the gastrointestinal tract (Walker and Coe, 1990).

Contaminants are introduced into the marine environment in various ways: sewage, rivers, urban and agricultural run-off, direct dumping at sea, fish farms, shipping, oil pollution and atmospheric inputs (Parsons *et al.*, 2000b; Parsons *et al.*, 2007). Among chemical pollutants, trace elements/heavy metals, polynuclear aromatic hydrocarbons (PAHs) and other hydrocarbons, organochlorines, radionuclides and butyltins are of major concern, while biological contaminants (such as sewage pathogens) and the excess of nutrients should also be considered. Observed and potential effects of chemical contaminants on cetaceans include immune-suppression (which contributes to a higher vulnerability to viral, bacterial and protozoan infections, increasing the risk of mortality), disruption of reproductive systems, liver toxicity, cancer promotion and neurological damage. Pathogens can also promote immune-suppression and introduce human and livestock diseases into wild animals (Parsons *et al.*, 2007; Waring *et al.*, 2009).

Due to their high trophic level and extended lifespans, cetaceans are highly vulnerable to bioaccumulation of contaminants, and some may pass from females to their calves during pregnancy and lactation, building up in the individuals since the very beginning of their lives (Parsons *et al.*, 2007; Waring *et al.*, 2009). Many contaminants might also have synergistic effects, even at low concentration levels, as they can combine or exacerbate each other's effects (e.g. sewage pathogens can take advantage of weakened immune systems, thus enhancing the effects of other contaminants). Therefore, pollutants should not be considered in isolation, but as part of a group of stressors (Parsons *et al.*, 2007).

iv. Ship collisions

All types and sizes of vessels potentially can hit cetaceans, although the most lethal and severe injuries come from ships of ≥80 m in length and those travelling ≥ 14 knots (26 km/h) (Laist, 2001). Of particular concern are high-speed ferries (Evans, 2009) and whale-watching vessels, as they target areas of high cetacean abundance and they are increasing in size and speed (Parsons *et al.*, 2007). Nevertheless, others such as cargo and navy ships, passenger vessels, private recreational boats, commercial fishing vessels and research vessels have also been documented to hit cetaceans (Laist, 2001). Large baleen whales and slower toothed whales (e.g. sperm and pilot whales) are usually the most affected species, though many other species frequently bear propeller-like and other boat-related scars (Laist, 2001; Evans, 2009). Even though most cetacean populations are probably not largely affected by this mortality, small local populations and discrete groups may be severely endangered. Due to the higher concentrations of both vessels and whales, most ship strikes appear to occur over or near the continental shelf (Laist, 2001). Furthermore, accounts of vessel collisions are increasing, not only because of the increase of high speed ships but also of the increase in reported incidents owing to a higher awareness for conservation (Parsons *et al.*, 2007).

v. Noise

The majority of anthropogenic sounds at sea range between the frequencies of 10 Hz and 500 Hz, though many scientific, military and even recreational boats' sonar systems produce sounds between 1 kHz and 500 kHz (Evans, 2003), but noise can be originated by various sources (Table I). On the other hand, odontocetes have the greatest hearing sensitivity above 50kHz whereas for mysticetes it is usually below 1 kHz. The produced sounds of many cetaceans range from 160 dB to 200 dB re. 1 μPa at 1m distance (Würsig and Richardson, 2002; Evans, 2003). Even though the sound ranges that many cetaceans hear and produce are already known, it is not known whether these are indicative of the levels they might tolerate. Despite this, mysticetes are probably more sensitive to noise frequencies below 5 kHz, while odontocetes may be particularly affected by frequencies above 1 kHz (Evans, 2003).

Noise has been linked to behavioural and physiological changes, and even to direct mortality (Parsons *et al.*, 2007; Waring *et al.*, 2009). Behavioural effects include changes in surface behaviour and vocalisations, while physiological effects comprise hearing damage (Temporary (TTS) or Permanent Thresholds Shifts (PTS)) and ear injury (Evans, 2002; Gordon *et al.*, 2004; Parsons *et al.*, 2007). These impacts may lead to alterations in migratory paths, disruption of social groups, disorientation, panic and, consequently, mass strandings (Gordon *et al.*, 2004).

Indirect interactions include the affection of prey abundance, behaviour and distribution, thus affecting cetaceans (Gordon *et al.*, 2004; Parsons *et al.*, 2007; Waring *et al.*, 2009). Effects at a population level have not been studied in detail but it is possible that noise-induced chronic stress may change reproductive rates and immune system function and, subsequently, increase mortality rates (Parsons *et al.*, 2007).

Table I – Anthropogenic noise sources in the ocean

Source	Examples	Effects of greatest concern
Transportation	Aircrafts, ships, boats, icebreakers, hovercraft and vehicles on ice	1, 2, 3, 4
Dredging and construction	Tunnel boring, pile driving	2, 3, 4, 5, 6
Oil and gas production	Seismic exploration, drilling and extraction	3, 4, 5, 6
Geophysical surveys	Air-guns, sleeve exploders and gas guns	1, 2, 3, 4, 5, 6
Sonars	Commercial (including fish finders, depth sounders), scientific and military	1, 3, 4, 5, 6
Ocean science studies	Seismology and acoustic propagation, tomography and thermography	1, 3, 4, 6
Acoustic alarms	Acoustic deterrent devices (ADDs or 'pingers') and acoustic harassment devices (AHDs or 'seal-scrammers')	4
Offshore windfarms	Construction, operation and decommissioning	1, 2, 3, 4, 5, 6
Military activities	Communication systems, explosions and firing ranges	3, 4, 5, 6

Notes: Effects of greatest concern (Boyd, 2008): 1 – Masking; 2 – Habitat displacement; 3 – Behavioural change; 4 – Behaviourally-mediated effects; 5 – Physical trauma; 6 – Hearing loss. References: Richardson *et al.*, 1995; Evans, 2002; Parsons *et al.*, 2007.

vi. Whale-watching

Whale-watching activities have emerged in many countries (namely in those with a whaling tradition), introducing a new and expanding economic activity (Waring *et al.*, 2009). This brings concern on the disturbance of target species, particularly due to noise and presence of large numbers of boats (Lusseau, 2006). Such disturbance may induce behavioural changes, such as increasing swimming speeds, dive times/depths and angle between successive dives (Magalhães *et al.*, 1999; Williams *et al.*, 2002), the adoption of a more erratic/less predictable path in order to avoid vessels (Bejder *et al.*, 1999; Magalhães *et al.*, 1999; Williams *et al.*, 2002), changing the duration and timing of resting behaviour (Constantine *et al.*, 2004; Visser *et al.*, 2006), forming more compact groups when in presence of boats (Bejder *et al.*, 1999) or changing acoustic behaviour (Erbe, 2002). This disturbance is thought to possibly affect small, closed, resident or endangered species, through a long term decline in abundance (Bejder *et al.*, 1999).

vii. Climate change

Climate change events such as rising sea levels, decreasing sea-ice cover and changes in temperature, ocean currents, salinity, CO_2, pH, rainfall patterns, storm frequency, wind speed, wave conditions and general climate patterns (Parsons *et al.*, 2007) have a worldwide potential to affect all species, including cetaceans (Learmonth *et al.*, 2006; Moore, 2009; Waring *et al.*, 2009). These changes may affect plankton abundance and distribution, directly affecting baleen whales and consequently affecting toothed whales through changes in their food webs (Learmonth *et al.*, 2006; Parsons *et al.*, 2007). Direct effects on cetaceans range from behavioural changes, increased vulnerability to diseases, decreased reproductive success, changes in geographical distribution, and, more extremely, mass die-offs (Azzellino *et al.*, 2008; Evans, 2009).

2. METHODOLOGY

While aiming to analyse North-East Atlantic (NEA) cetaceans' habitat needs and the effects of human activities on them, an extensive literature review on these subjects was conducted to obtain and extract all relevant published information, and codes were assigned to each characteristic/category. Statistical analyses were then applied to the resulting data to check for the existence of groups of species and, if possible, define guilds. Existing conservation instruments were reviewed as an aid to examine the implications of the results of the groupings obtained in the context of conservation goals.

2.1. Data Collection

Information about global species' habitat preferences and registered human activities' impacts for the NEA waters was compiled from selected sources amongst primary and secondary references. The collected data ranged from statistically significant results of research studies (e.g. Rogan & Mackey 2007, Azzellino et al. 2008), institutional reports (e.g. IWC 2008), conference proceedings (e.g. Walker & Coe 1990) and review articles (e.g. Parsons 2000b, Waring et al. 2009), to more qualitative broad descriptions (e.g. Baker 1978, Jefferson et al. 1993). These sources provided different types of data, from precise values (e.g. 200 m deep or "five individuals hit by ships") to general statements (e.g. tropical waters or "animals were caught in gillnets"). These data were recorded according to the criteria on section 2.2 and compiled as a presence/absence data matrix. Additionally, information on present conservation instruments' objectives was also compiled, and the species to which these instruments refer to were listed.

Information about habitat needs was available for all species. In contrast, no information was found for interactions with human activities for the pigmy killer whale (*Feresa attenuata*), pygmy and dwarf sperm whales (*Kogia breviceps* and *K. sima*, respectively), Fraser's dolphin (*Lagenodelphis hosei*), narwhal (*Monodon monoceros*), melon-headed whale (*Peponocephala electra*), false killer whale (*Pseudorca crassidens*), Atlantic spotted dolphin (*Stenella frontalis*) and rough-toothed dolphin (*Steno bredanensis*) in the NEA.

2.2. Matrix Construction

2.2.1. Habitat Needs

i. Depth

Depth range was defined as epipelagic (0-200 m – *DO1* and *DO2*), mesopelagic (200-1000 m – *DO3*), higher bathypelagic (1000-2000 m – *DO4*) and lower bathypelagic (2000-4000 m – *DO5*) provinces (Nybakken and Bertness, 2005). The epipelagic province was then divided in two categories in order to distinguish those animals that may come to feed in inshore areas, such as bays and estuaries (0-10 m – *DO1*) from those that stay further offshore (10-200 m – *DO2*).

ii. Sea Surface Temperature (SST)

Preferred average SST was translated in temperature-related oceanic regions, with their dynamic boundaries, changing throughout the year and with the changes in oceanic currents' patterns. The range was, therefore, defined as the Polar (<9°C – *TO1*), Cold Temperate (Subpolar, 10°-19°C – *TO2*), Subtropical (Warm Temperate, 20°-24°C – *TO3*) and Tropical (>25°C – *TO4*) regions (Castro and Huber, 2003).

iii. Season

Seasons were defined based on the principle that the ocean's thermal inertia is higher than the land's one (Trujillo and Thurman, 2005). Therefore, each season was considered to start in the month after each solstice/equinox such that: Winter – January to March (*1*); Spring – April to June (*2*); Summer – July to September (*3*); and Autumn – October to December (*4*). The season referred for each species corresponds to the season where the mating (*SM*) and calving (*SC*) peaks occur, although for some individuals or species this may occur across other seasons.

iv. Movements

Species were considered as Migratory (*MM*) when they are known to undergo long-distance (trans-oceanic) migrations and as Non migratory (*MNm*) when they have resident habits or take only short-range movements (e.g. inshore-offshore movements or with the retreat and advance of the arctic pack ice).

v. Typical group size

Ranges of group size were defined according to the data collected for the species and considering their tendency to be solitary or gregarious, defining:

- 1 as any solitary individual (*AG1*);
- 2 as any two individuals (one male + one female, two males, two females or female + calf – *AG2*);
- 3 as any small pods (three or more individuals clearly affiliated, usually one female and her offspring, and sometimes also one male – *AG3*);
- 4-10 (*AG4*), 11-20 (*AG5*), 21-50 (*AG6*), 51-100 (*AG7*), 101-500 (*AG8*), 501-1000 (*AG9*), >1000 (*AG10*) individuals as any group of individuals not necessarily related, usually cited in the literature as "forming groups up to *X* individuals". In these groups double presences were assumed up to the cited limit of the group size. Furthermore, when species were cited as forming groups of hundreds or thousands of individuals, presences were assumed in the categories 101-500 and 501-1000 individuals and in >1000 individuals, respectively.

vi. Prey Species

Prey species were grouped in categories according to the following criteria:

- Small zooplankton (*PZs*): any zooplanktont smaller than 1 cm in length (e.g. copepods, amphipods, eggs and invertebrate larvae)
- Large zooplankton (*PZl*): any zooplanktont larger than 1 cm in length (e.g. krill and fish larvae);
- Small fish (*PFs*): any fish species whose medium length is smaller than 25 cm (e.g. capelin and sprat);
- Large fish (*PFl*): any fish species whose medium length is larger than 25 cm (e.g. cod, haddock, halibut, sharks and rays);
- Cephalopods (*PCp*): squid, octopus and cuttlefish;
- Crustaceans (*PCr*): crabs and shrimps;
- Benthic invertebrates (*PBi*): marine worms, sea cucumbers, sea stars, etc.;
- Higher vertebrates (*PHv*): marine mammals and sea turtles.

vii. Feeding

Area refers to preferred water column position for feeding behaviour, distinguished here only between the Pelagic (*FA1*) and Demersal (*FA2*) environments.

Capture method refers to the preferred method used to capture prey. Filtering (*FCm1*) includes both skimming and gulping while Hunting (*FCm2*) refers to the active pursuit and capture of prey (Reeves *et al.*, 2002).

2.2.2. Human Activities

i. Whaling

Refers to any directed capture of cetaceans either for commercial, scientific or subsistence (by aboriginal/local hunters) purposes, in the past or at present (*W*).

ii. By-catch

Different fishing nets and methods were considered as leading to the incidental capture of cetaceans (gillnets/driftnets (*BcG*), trawls (*BcT*), purse seines (*BcPs*)). Particularly, Tuna fishery (*BcTf*) refers to the by-catch of cetaceans in purse seine nets that are dedicated to tuna fishing operations. This was included as a distinct activity because fisherman frequently explore the cooperative feeding that tunas and dolphins regularly exhibit, making the latter more vulnerable to the incidental capture in these than in other purse seine fisheries (Northridge, 2002). Traps (*BcPl*) include pot and lobster creel lines where the animals get entangled either in the actual traps or in the supporting cables.

iii. Fisheries

Besides by-catch, more indirect incidental threats were considered such as the *Entanglement* (*FEn*) in discarded or lost fishing nets.

iv. Contaminants

Records of significant concentrations of Trace elements (e.g. heavy metals – *CTe*), Polynuclear Aromatic Hydrocarbons (PAHs – *CPah*), Organochlorines (e.g. DDTs and PCBs – *CO*) and Butyltins (*CBu*) on cetaceans skin, blubber or organs were registered.

v. Ship collisions

Any records of collisions between any type of ship and cetaceans which led to the animals' death, or to injuries that were likely to be fatal, were registered in this category (*Sc*).

vi. Noise

Different noise sources were considered, amongst vehicles and activities, for which any records referring to behavioural changes (vocalisations, scaring, fleeing and avoidance of the area) in cetaceans were registered. Ships/boats (*NSh*) refers to changes in cetacean behaviour due to the noise from the presence and manoeuvring of vessels. Windfarms (*NWf*) refers to all aspects relating to implementation of offshore wind turbines: pre-construction, construction, operation and decommissioning (Nedwell *et al.*, 2007). Dredging (*ND*) refers to any sediment handling to deepen channels or harbours, to create land or submerged banks or for underwater aggregate mining (Richardson *et al.*, 1995). Seismic surveys (*NSs*) refer to the activities involving any geophysical surveys, such as oil and gas prospection and oceanographic research. Military activities (*NMa*) refers to any noise from military operations including use of sonar, explosions and firing ranges causing changes in behaviour and physical auditory damage in cetaceans (Richardson *et al.*, 1995; Parsons *et al.*, 2000a). Acoustic alarms (*NAl*) refer to persistent over-reactions to Acoustic Harassment Devices (AHDs) and Acoustic Deterrent Devices (ADDs) (Culik *et al.*, 2001).

vii. Whale-watching

Records of behavioural changes in the animals during whale-watching operations were registered in this category (*Ww*).

2.3. Data Analysis

2.3.1. Cetaceans of Interest

The OSPAR maritime area, in the North-East Atlantic, comprises five regions: Arctic Waters (I), Greater North Sea (II), Celtic Seas (III), Bay of Biscay and Iberian Coast (IV), and the Wider Atlantic (V). These waters are rich in marine life, including 35 cetacean species (ITIS, 2009), which were considered as the cetaceans of interest in this study (Table II).

2.3.2. Descriptive Analysis

A descriptive analysis was conducted on the collected data for both habitat needs and human activities to identify the frequency of species in each category. Column graphs were constructed using Microsoft® Office Excel 2007 (©2006 Microsoft Corporation), with the total number of species in each habitat need/human activity category; therefore, the same species may be counted more than once. Some human activities are registered as having negative impacts on cetaceans in other geographic regions and, although these have not been registered in the North-East Atlantic, they were also listed as providing complementary information.

2.3.3. Statistical Analysis

To look for trends in the collected complex multivariate data, there is a need to simplify it to fewer dimensions using multivariate techniques. Among these are Correspondence Analysis and Cluster Analysis. The Correspondence Analysis is an ordination method that summarizes the data in a diagram, placing closer together the species sharing the same attributes (R-mode), which can be applied to both presence/absence and abundance data (Legendre and Legendre, 1998). Classification is a multidimensional analysis that groups similar species into nested subsets, according to the attributes considered. The hierarchical agglomerative method used in this study was the group average (or unweighted arithmetic average clustering, UPGMA), where the distance between clusters is the average distance between all pairs of objects (isolated or in each previously formed cluster). The Jaccard's similarity coefficient was used as an asymmetrical binary coefficient, in which all terms have the same weight.

Regarding the habitat needs, the analyses were conducted to identify groups among the 35 species sharing similar needs, among the total of 42 categories

Table II– Cetaceans of the North-East Atlantic (Waring *et al.*, 2009), the codes assigned to each species in the analyses and their occurrence status in the OSPAR Commission (2000) regions

	Species	Common name	Code	OSPAR regions				
				I	II	III	IV	V
	Mysticeti							
Balaenidae	*Balaena mysticetus*	Bowhead whale*	Bmys	P				
Balaenidae	*Eubalaena glacialis*	Northern right whale*	Egla			P	P	P
Balaenopteridae	*Balaenoptera acutorostrata*	Minke whale	Bacu	P	P	P	P	P
Balaenopteridae	*Balaenoptera borealis*	Sei whale†	Bbor	P	V	V	P	P
Balaenopteridae	*Balaenoptera brydei*	Bryde's whale	Bbry				V	V
Balaenopteridae	*Balaenoptera musculus*	Blue whale‡	Bmus	P	V	V	P	P
Balaenopteridae	*Balaenoptera physalus*	Fin whale	Bphy	P‡	P	P	P	P‡
Balaenopteridae	*Megaptera novaeangliae*	Humpback whale	Mnov	P‡	P	P	P	P‡
	Odontoceti							
Delphinidae	*Delphinus delphis*	Common dolphin	Ddel	P	P	P	P	P
Delphinidae	*Feresa attenuata*	Pygmy killer whale†	Fatt					P
Delphinidae	*Globicephala macrorhynchus*	Short-finned pilot whale	Gmac				P	P
Delphinidae	*Globicephala melas*	Long-finned pilot whale	Gmel	P	P	P	P	P
Delphinidae	*Grampus griseus*	Risso's dolphin	Ggri		P	P	P	P
Delphinidae	*Lagenodelphis hosei*	Fraser's dolphin±	Lhos		V	V	V	V
Delphinidae	*Lagenorhynchus acutus*	Atlantic white-sided dolphin	Lacu	P	P	P	P	P
Delphinidae	*Lagenorhynchus albirostris*	White-beaked dolphin	Lalb	P	P	P	P	V
Delphinidae	*Orcinus orca*	Killer whale	Oorc	P	P	P	P	P
Delphinidae	*Peponocephala electra*	Melon-headed whale	Pele					P
Delphinidae	*Pseudorca crassidens*	False killer whale	Pcra				V	P
Delphinidae	*Stenella coeruleoalba*	Striped dolphin	Scoe			P	P	P
Delphinidae	*Stenella frontalis*	Atlantic spotted dolphin	Sfro				V	P
Delphinidae	*Steno bredanensis*	Rough-toothed dolphin	Sbre				P	P
Delphinidae	*Tursiops truncatus*	Bottlenose dolphin	Ttru		P	P	P	P
Hyperoodontidae	*Hyperoodon ampullatus*	Northern bottlenose whale	Hamp	P	V	V	P	P
Hyperoodontidae	*Mesoplodon bidens*	Sowerby's beaked whale†	Mbid	P	V	V	P	P
Hyperoodontidae	*Mesoplodon densirostris*	Blainville's beaked whale†	Mden				V	V
Hyperoodontidae	*Mesoplodon europaeus*	Gervais' beaked whale†	Meur					V
Hyperoodontidae	*Mesoplodon mirus*	True's beaked whale†	Mmir			V	V	V
Hyperoodontidae	*Ziphius cavirostris*	Cuvier's beaked whale†	Zcav	V	V		P	
Kogiidae	*Kogia breviceps*	Pygmy sperm whale†	Kbre				P	P
Kogiidae	*Kogia sima*	Dwarf sperm whale†	Ksim				V	V
Monodontidae	*Delphinapterus leucas*	Beluga	Dleu	P				
Monodontidae	*Monodon monoceros*	Narwhal†	Mmon	P				
Phocoenidae	*Phocoena phocoena*	Harbour porpoise	Ppho	P	P	P	P	P
Physeteridae	*Physeter macrocephalus*	Sperm whale	Pmac	P	V	V	P	P

NOTES: Taxonomy according to ITIS (2009). P – species is present in the region; V – vagrant animals, these are mostly species that normally occur in deep water, or are tropical species; * Numbers substantially below 'natural' levels due to past hunting; † The status of most of the beaked whales and some other whales is poorly known; ‡ Below or substantially below 'natural' levels;± this species is not referred in OSPAR QSR2000, but has been referred as vagrant for British (Evans and Hammond, 2004), French, Portuguese and/or Macaronesian waters (Waring *et al.*, 2009).

(which were assigned different codes as denoted in section 2.2.1 and in Appendix I).

A critical examination was conducted on the validity of the collected data on human activities for statistical analysis. For all types of *Contaminants* the existing records only report the presence of a certain amount of the substances but it is not certain whether these actually constitute a threat to the species. Therefore, *Contaminants* were considered as not comparable with the other activities, thus not suitable to include in the statistical analysis, and were only used in the descriptive analysis.

In addition, some activities only registered a single presence for one species, which was considered as a factor biasing the analysis, particularly by distorting the dispersion of the affected species in the Correspondence Analysis. Therefore by-catch with Traps (*BcPl*), Entanglements in fishing nets (*FEn*) and noise from Dredging (*ND*), Windfarms (*NWf*) and Acoustic alarms (*NAl*) were also excluded from the multivariate statistical analysis. As a result, the analysed activities were: whaling, by-catch (all net types except traps), ship collisions, noise from ships/boats, seismic surveys and military activities, and whale-watching activities, which were classified into a total of 10 categories and assigned different codes (as indicated in section 2.2.2 and Appendix II).

Correspondence analyses were performed using MVSP© v.3.13q (©Kovach Computing Services), where joint plots were generated, showing the distribution of the species in the ordination space, and their relationships to both the ordination axes and the habitat needs/human activities. Cluster analyses were performed using PRIMER v.6.1.6 (©2006 PRIMER-E Ltd) for the construction of species-grouping trees, identified according to the groups considered in the Correspondence Analyses.

3. RESULTS

In this chapter, data obtained on habitat needs and human activities were organized in presence/absence matrices (see appendices I and II respectively), which were then analysed descriptively, through bar graphs, and statistically, through correspondence analysis and cluster analysis. Data on species status in the fifteen conservation instruments was also compiled in a matrix (see appendix III).

3.1. Habitat Needs

Overall, the cetacean fauna of the North-East Atlantic (NEA) shows a preference for depths between 200-2000 m and subtropical/tropical waters; they avoid reproducing in autumn, preferring spring and summer, for mating and calving respectively (although numbers in winter are not much lower) and most species are non migratory (Fig. 1).

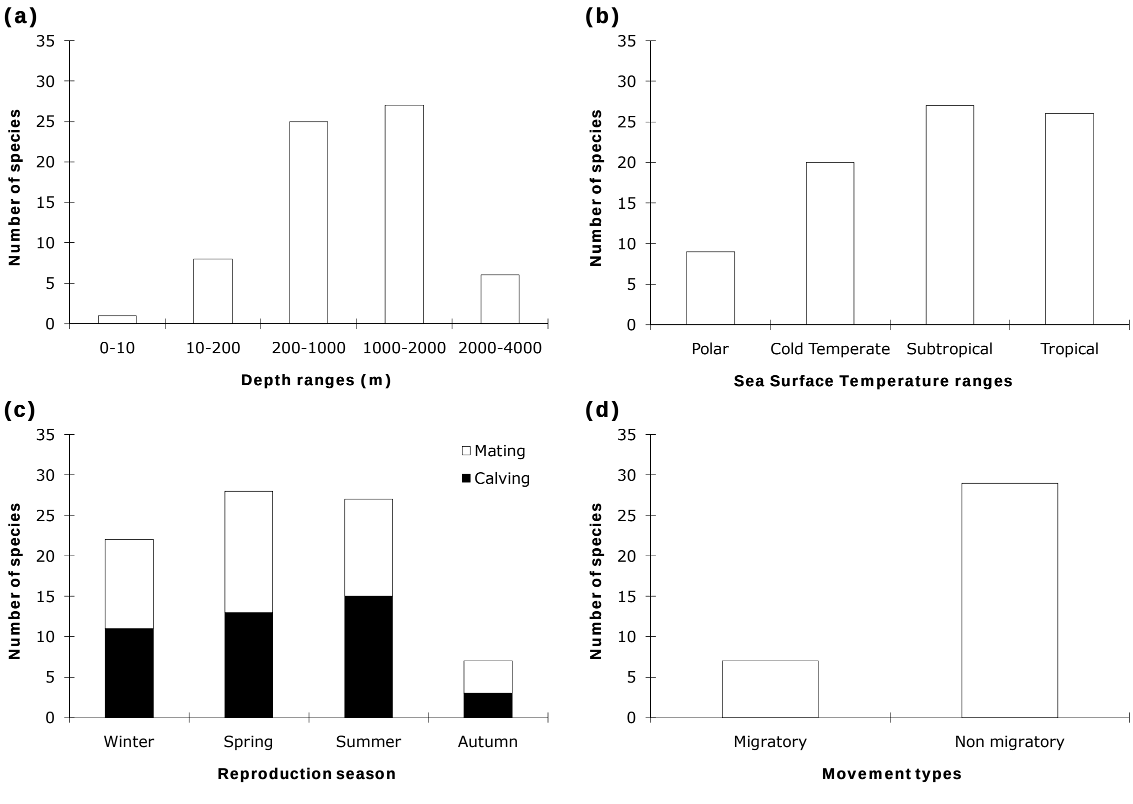

Figure 1. Number of North-East Atlantic species according to habitat needs: (a) depth ranges of occurrence (m); (b) Sea Surface Temperature ranges of occurrence; (c) peak season for reproduction; (d) migratory movements' types (vertical axes were kept similar to allow direct comparison). Note that some species contribute to more than one category.

Cetaceans in the NEA frequently live solitary or in groups up to 12 individuals; small fish and cephalopods are the main prey species consumed by NEA cetaceans, which mainly feed in the pelagic area and through direct hunting of prey items (Fig. 2).

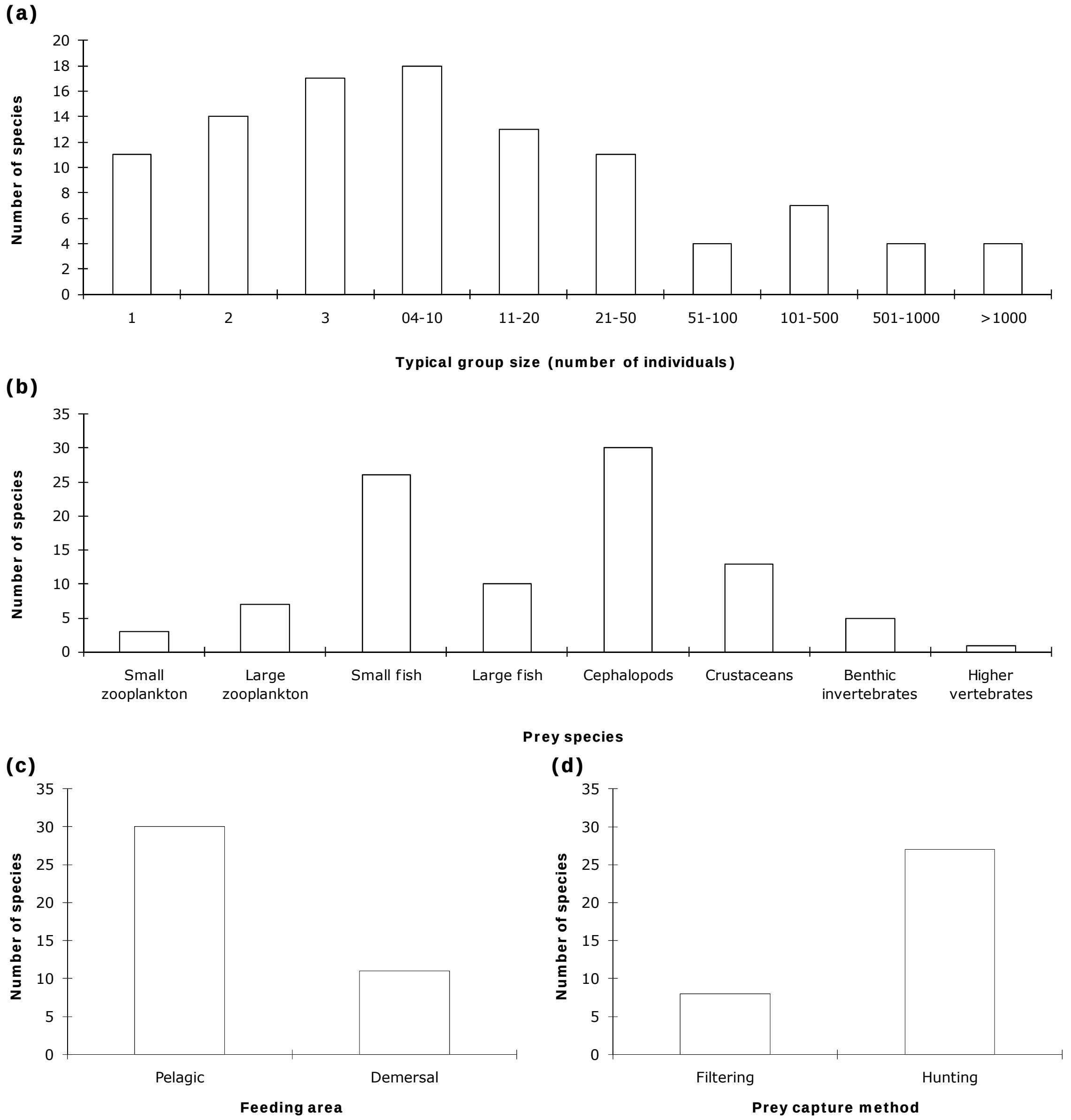

Figure 2. Number of North-East Atlantic species according to habitat needs: (a) typical group size (b) preferred prey species; (c) preferred feeding area; (d) preferred prey capture method. Note that some species contribute to more than one category.

The correspondence analysis between habitat needs and cetacean species showed the presence of 2 groups along the first ordination axis (Fig. 3): mysticetes (to the left) and odontocetes (to the right).

The group 1, of mysticetes (*Balaenoptera acutorostrata* (Bacu), *B. borealis* (Bbor), *B. brydei* (Bbry), *B. musculus* (Bmus), *B. physalus* (Bphy), *Eubalaena glacialis* (Egla), *Megaptera novaeangliae* (Mnov) and *Balaena mysticetus* (Bmys)), was clearly defined by their preference for the lower bathypelagic province (*DO5*), by mating and calving in the winter (*SM1* and *SC1*), by living usually alone or in pairs (*AG1* and *AG2*), by pursuing long distance migrations (*MM*) and by feeding on zooplankton (*PZs*, *PZl*) through filtration (*FCm1*) (Fig. 4). *Balaena mysticetus* (Bmys) is placed in an outer position in this group due to its preference for the lower epipelagic region (*DO2*) and for forming small pods (*AG3*).

The main variables characterizing the odontocetes' group, distinguishing it from the mysticetes, were the preference for mating in the summer and autumn (*SM3* and *SM4*), for forming groups of 13-20 individuals (*AG5*) and for not undertaking long distance migrations (*MNm*) (Fig. 5).

The odontocetes were found to be dispersed radially from a region around the origin of the axes to the positive direction of factor 1 in the diagram (Fig. 5). The presence of several odontocete species in the central sector (group 2) may be related to those species' rarity in the area (with only few presences for few characteristics, resulting in a considerable amount of missing values in the matrices – e.g. *Mesoplodon bidens* (Mbid), *M. densirostris* (Mden), *M. europaeus* (Meur) and *M. mirus* (Mmir)); to ubiquity (distribution equally related to most of the considered variables – e.g. *Orcinus orca* (Oorc) and *Physeter macrocephalus* (Pmac)); or to having mixed preferences (sharing preferences that characterize the other groups – e.g. *Grampus griseus* (Ggri) and *Pseudorca crassidens* (Pcra)).

From this central area, two tendencies may be noted along the bisecting-lines of the first and second quadrants (Fig. 5). In the first quadrant (group 3), the species *Hyperoodon ampullatus* (Hamp), *Lagenorhynchus albirostris* (Lalb), *Monodon monoceros* (Mmon), *Phocoena phocoena* (Ppho), *Stenella frontalis* (Sfro) and *Tursiops truncatus* (Ttru) were characterized by the preference for the higher epipelagic province (*DO1*), for polar temperatures (*TO1*), for calving in summer (*SC3*), and for feeding on large fish (*PFl*) and crustaceans (*PCr*), in the demersal area (*FA2*). For this group, the preference for the higher epipelagic area (*DO1*) is in an exterior area of the diagram because it registers only one presence for the species *Phocoena phocoena* (Ppho), once this is the species that most frequently reaches inner coastal areas such as bays and estuaries.

In the second quadrant (group 4), the species *Delphinus delphis* (Ddel), *Globicephala macrorhynchus* (Gmac), *Globicephala melas* (Gmel),

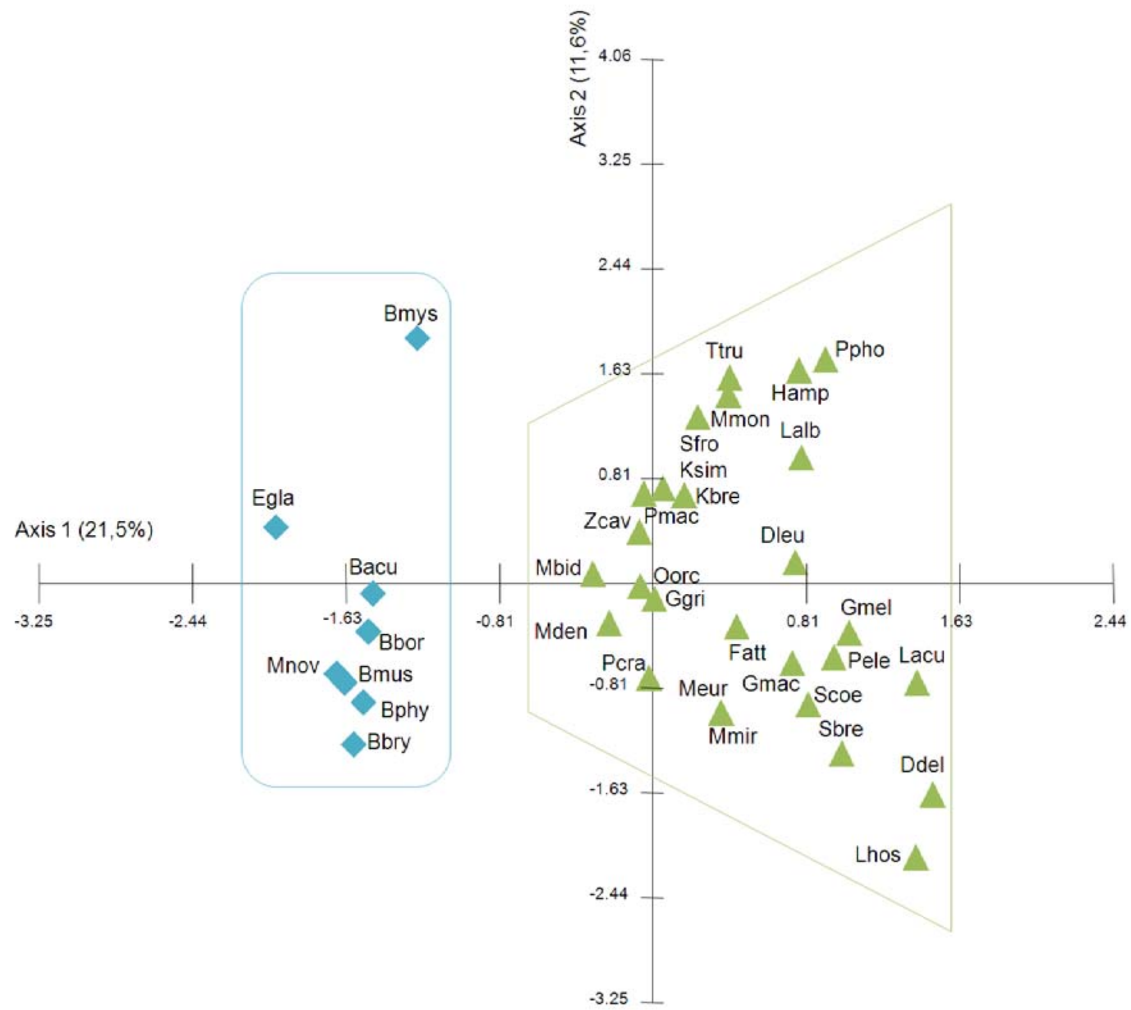

Figure 3. Correspondence analysis diagram showing mysticetes (blue) and odontocete (green) species, represented by the assigned codes (Appendix I). Different symbols and colours indicate the identified groups.

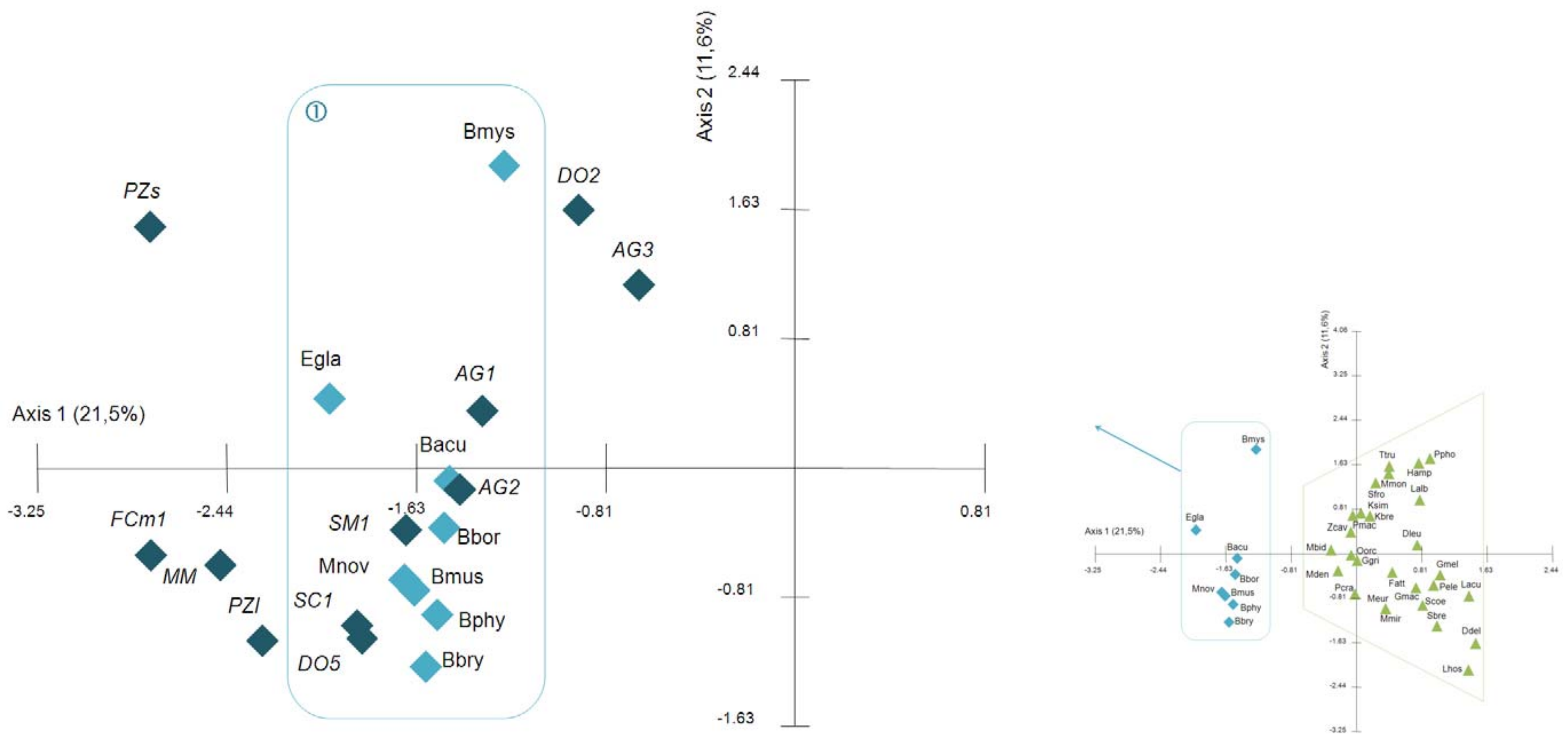

Figure 4. Detail of the correspondence analysis joint diagram (fig. 3) with habitat needs (dark blue) and mysticete species (light blue), represented by the assigned codes (Appendix I).

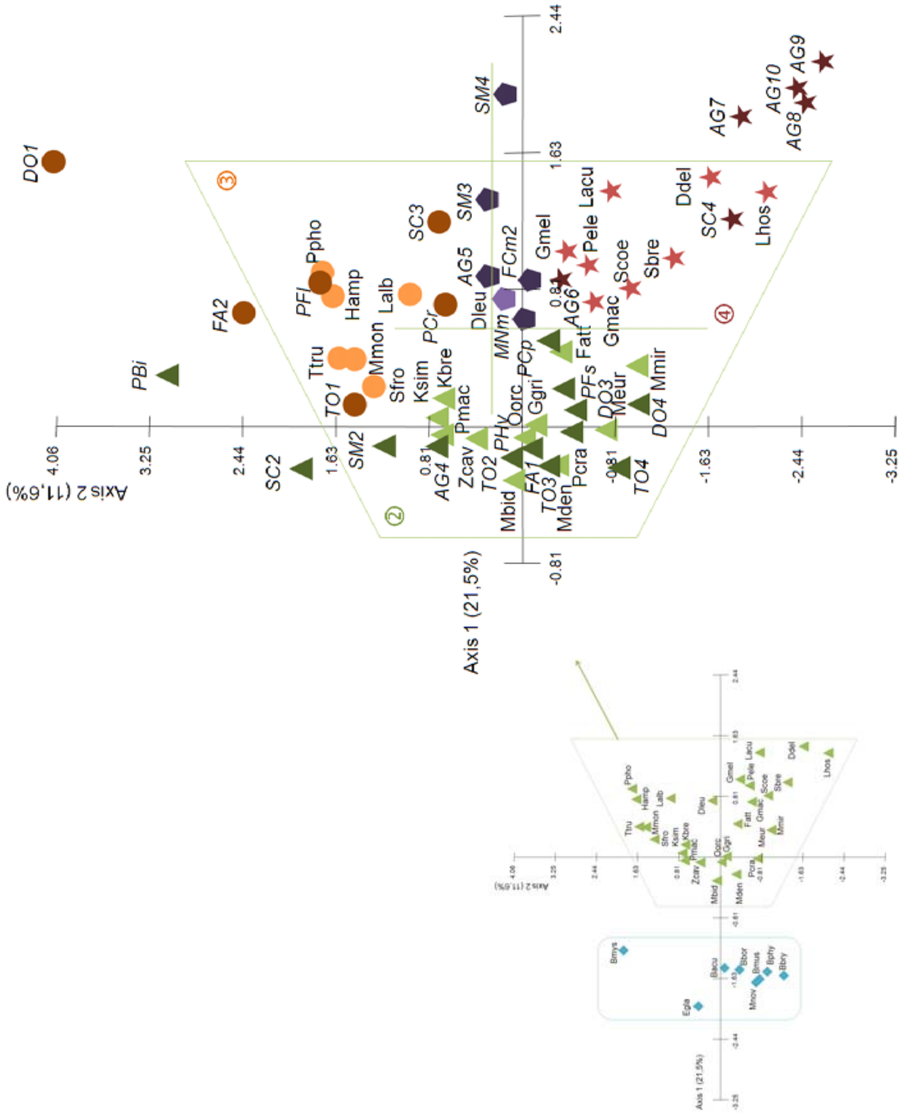

Figure 5. Detail of the correspondence analysis joint diagram with habitat needs (dark colour) and odontocete species (light colour), represented by the assigned codes (Appendix I), showing the central sector (green), the first (orange) and the second (red) quadrant tendencies and other species/categories (purple).

Lagenorhynchus acutus (Lacu), *Lagenodelphis hosei* (Lhos), *Peponocephala electra* (Pele), *Steno bredanensis* (Sbre) and *Stenella coeruleoalba* (Scoe) were assembled by their preference for calving in the autumn (*SC4*), by forming aggregates with 21-10000 individuals (*AG6*, *AG7*, *AG8*, *AG9* and *AG10*) and by actively hunting for their prey (*FCm2*). The species *Delphinapterus leucas* (Dleu) was placed very close to the first axis, in the midline between the two tendencies described above.

The cluster analysis placed the mysticetes and the odontocetes in different groups (Fig. 6), as with the correspondence analysis. Amongst the odontocetes, the patterns identified in the correspondence analysis were not so clear in the clusters.

The species in the central sector and the first quadrant appeared in mixed clusters, while the species from the second quadrant appeared all together in one cluster (although two species of the central sector were also in this cluster). It may be graphically appreciated that correspondence analysis provides much better discrimination than conventional cluster analysis.

These analyses show that the odontocetes cannot be defined into separate groups and the distributions of the species can only be described as following the previously explained trends.

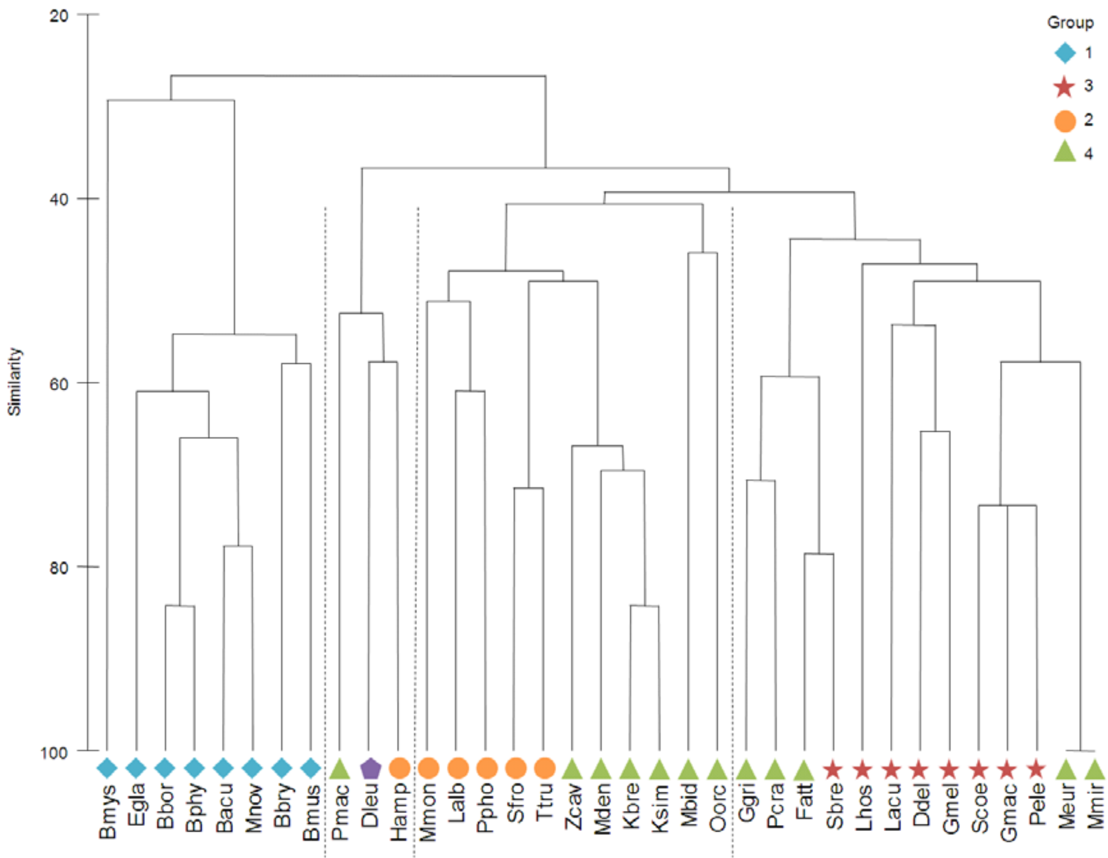

Figure 6. Cluster analysis of species according to habitat needs, with the symbol/colour codes as in the correspondence analysis (Figs. 3-5).

3.2. Human Activities

Seismic surveys was the noise source which, according to the recorded data, disturbed more species in the North-East Atlantic (NEA), with noise from ships/boats and military activities affecting also a few species (Fig. 7). By-catch in tuna fisheries, gillnets/driftnets and trawls had an influence on many species, as well as collisions with ships and whaling. By-catch in long lines, debris ingestion, prey depletion and noise from aircrafts, icebreaking, hovercraft, hydrofoils and jet skis, offshore drilling, offshore oil and gas production, sonars and explosions are activities which have negatively affected cetaceans in many geographic areas, although not registered for the NEA.

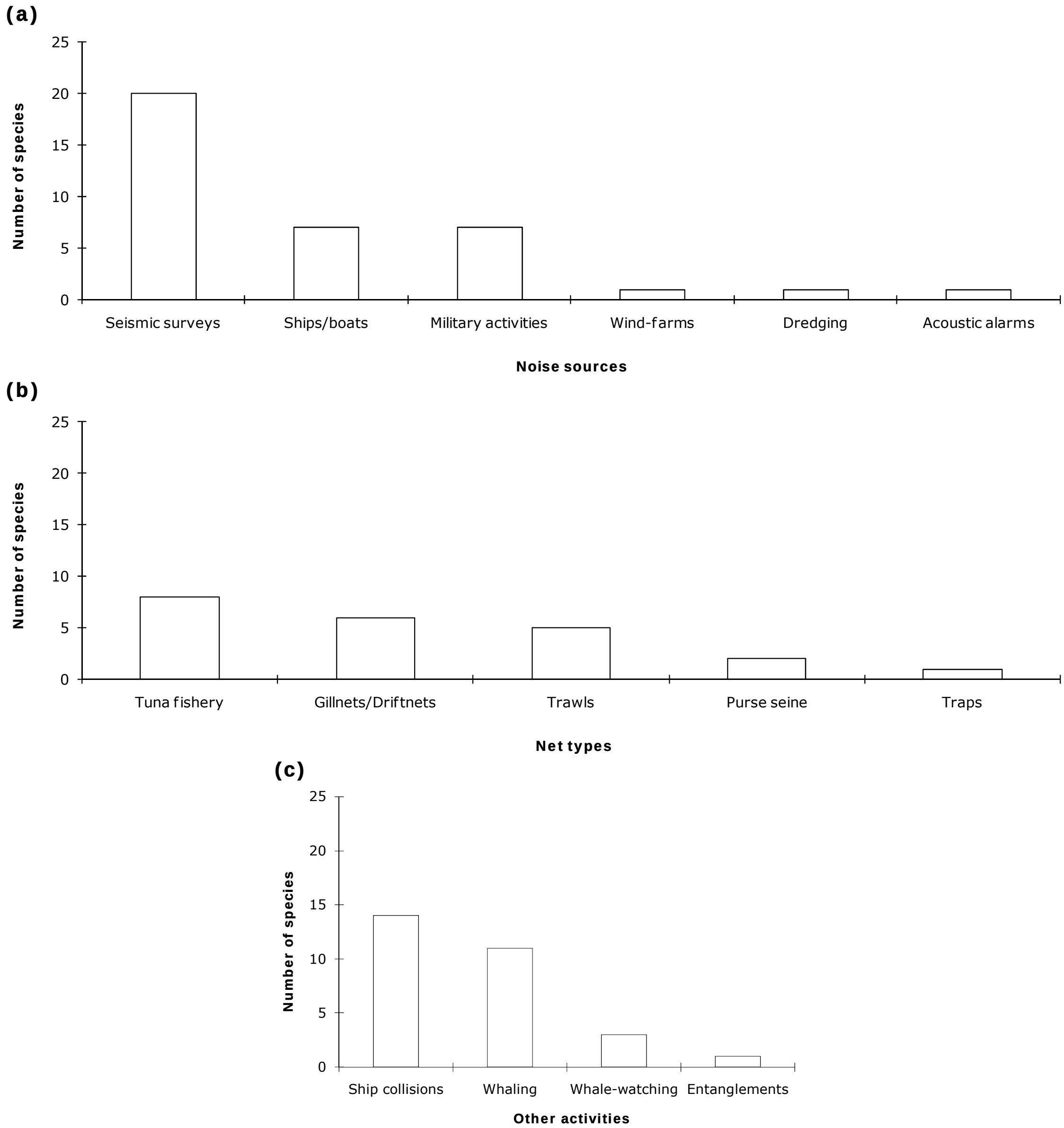

Figure 7. Number of species affected by various types of human activities in the North-East Atlantic. (a) noise sources; (b) by-catch per net type; (c) other activities (vertical axes were kept similar to allow direct comparison).

In terms of contaminants (Fig. 8), organochlorines, trace elements and butyltins have been found in many species, while PAHs are much less frequent. However, there were no records of the presence of contaminants in more than half of the species (Table III), which may be due to insignificant levels of contaminants in some species and/or to a lack of tissue analysis in others.

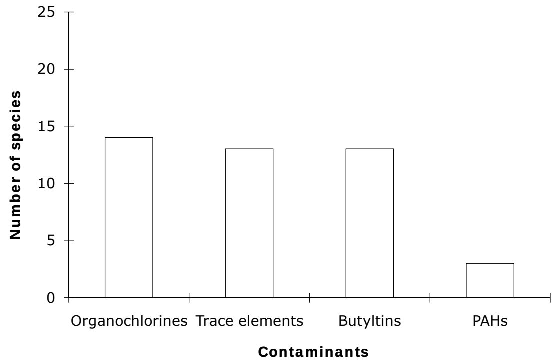

Figure 8. Number of species with contaminant levels by contaminant type, in the North-East Atlantic.

It is of note that nine species (*Balaenoptera acutorostrata*, *Delphinus delphis*, *Globicephala melas*, *Grampus griseus*, *Lagenorhynchus acutus*, *Mesoplodon bidens*, *Mesoplodon densirostris*, *Stenella coeruleoalba* and *Tursiops truncatus*) were found contaminated by the same three compounds (trace elements, butyltins and organochlorines) (Table III).

Table III –Presence/absence of each type of contaminants in the NEA cetacean species (species are disposed according to decreasing order of the total number (Sum) of different contaminants registered for each species)

Species	PAHs	Trace elements	Butyltins	Organochlorines	Sum
Phocoena phocoena	✓	✓	✓	✓	4
Physeter macrocephalus	✓	✓		✓	3
Balaenoptera acutorostrata		✓	✓	✓	3
Delphinus delphis		✓	✓	✓	3
Globicephala melas		✓	✓	✓	3
Grampus griseus		✓	✓	✓	3
Lagenorhynchus acutus		✓	✓	✓	3
Mesoplodon bidens		✓	✓	✓	3
Mesoplodon densirostris		✓	✓	✓	3
Stenella coeruleoalba		✓	✓	✓	3
Tursiops truncatus		✓	✓	✓	3
Balaenoptera physalus			✓	✓	2
Delphinapterus leucas	✓			✓	2
Lagenorhynchus albirostris		✓	✓		2
Orcinus orca		✓		✓	2
Hyperoodon ampullatus			✓		1
Balaena mysticetus, *Balaenoptera borealis*, *Balaenoptera brydei*, *Balaenoptera musculus*, *Eubalaena glacialis*, *Feresa attenuata*, *Globicephala macrorhynchus*, *Kogia breviceps*, *Kogia sima*, *Lagenodelphis hosei*, *Megaptera novaeangliae*, *Mesoplodon europaeus*, *Mesoplodon mirus*, *Monodon monoceros*, *Peponocephala electra*, *Pseudorca crassidens*, *Stenella frontalis*, *Steno bredanensis*, *Ziphius cavirostris*					0

The correspondence analysis diagram (Fig. 9) revealed the presence of three groups of species. The species *Balaenoptera borealis* (Bbor), *B. musculus* (Bmus), *B. physalus* (Bphy), *Eubalaena glacialis* (Egla), *Megaptera novaeangliae* (Mnov) and

Balaena mysticetus (Bmys) formed group A, which was related to whaling (*W*) and noise from ships/boats (*NSh*). The species *Balaenoptera brydei* (Bbry), *Delphinus delphis* (Ddel), *Grampus griseus* (Ggri), *Globicephala macrorhynchus* (Gmac), *G. melas* (Gmel), *Lagenorhynchus albirostris* (Lalb), *Mesoplodon bidens* (Mbid), *Orcinus orca* (Oorc), *Phocoena phocoena* (Ppho), *Stenella coeruleoalba* (Scoe) and *Tursiops truncatus* (Ttru) formed group B, under the influence of all considered by-catch activities (*BcG*, *BcT*, *BcP*s and *BcTf*), collisions with ships (*Sc*) and disturbance from whale-watching operations (*Ww*). Finally, the species *Balaenoptera acutorostrata* (Bacu), *Mesoplodon densirostris* (Mden), *M. europaeus* (Meur), *M. mirus* (Mmir), *Physeter macrocephalus* (Pmac) and *Ziphius cavirostris* (Zcav) formed group C, related to noise from seismic surveys (*NSs*) and military activities (*NMa*).

The species *Lagenorhynchus acutus* (Lacu) was located in the centre of the diagram, which indicates that it was not possible to characterize this species according to the analysed activities, possibly because it is affected by activities that are related to all the other groups. Similarly, *Hyperoodon ampullatus* (Hamp) was positioned intermediate between groups A and C, which may indicate that activities affecting these two groups also affect this species. *Delphinapterus leucas* (Dleu) was found in an outer position because it was only registered to be affected by noise from ships/boats (*NSh*).

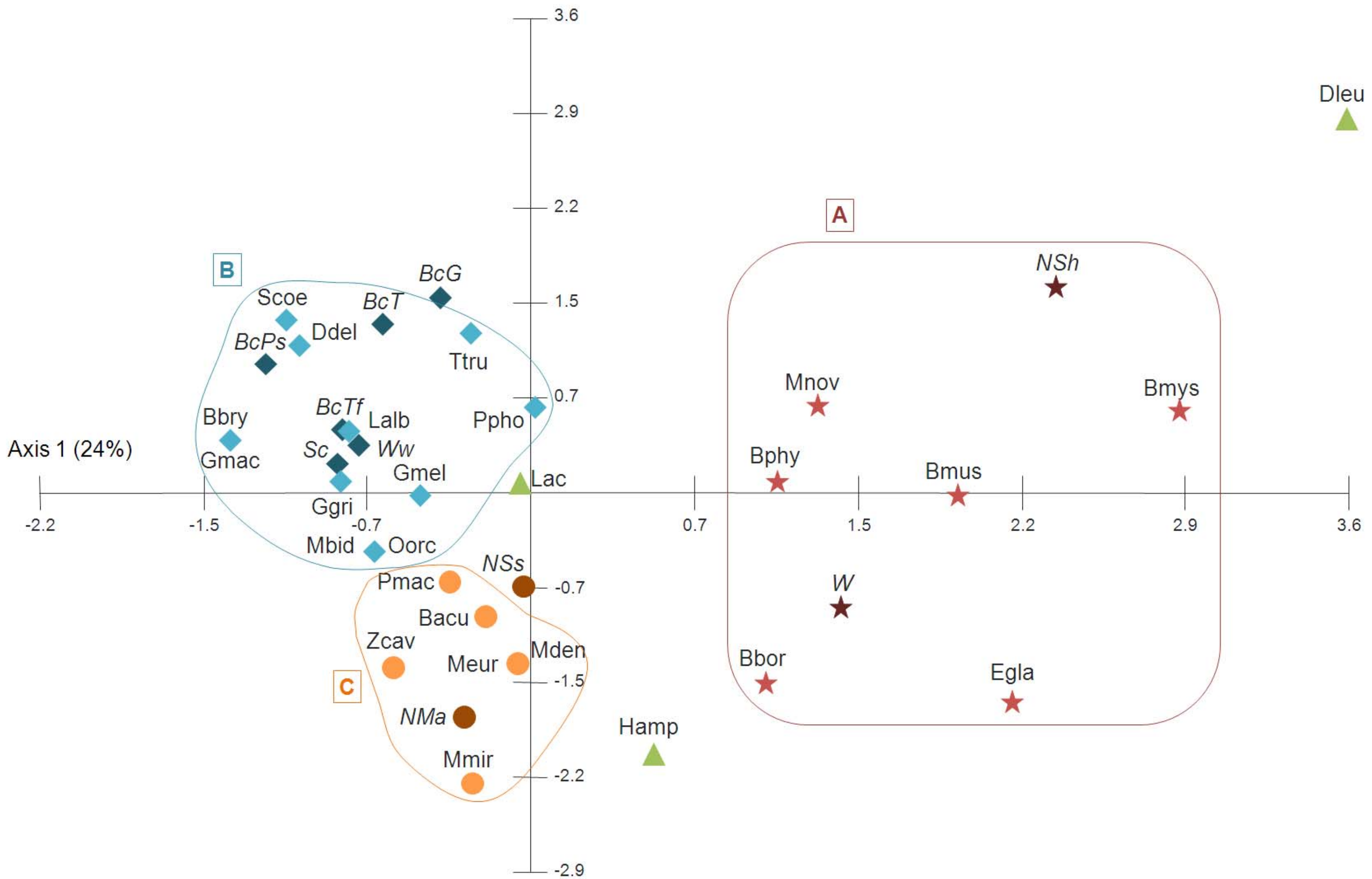

Figure 9. Correspondence analysis diagram between human activities (dark colour) and species (light colour), represented by the assigned codes (Appendix II). Different symbols and colours indicate the identified groups.

The cluster analysis (Fig. 10) showed groups different from those identified in the correspondence analysis. Although most species of group A clustered together, as did many species of group B, overall, this analysis could not clearly confirm the groups previously identified, which may be due to the scarcity of data.

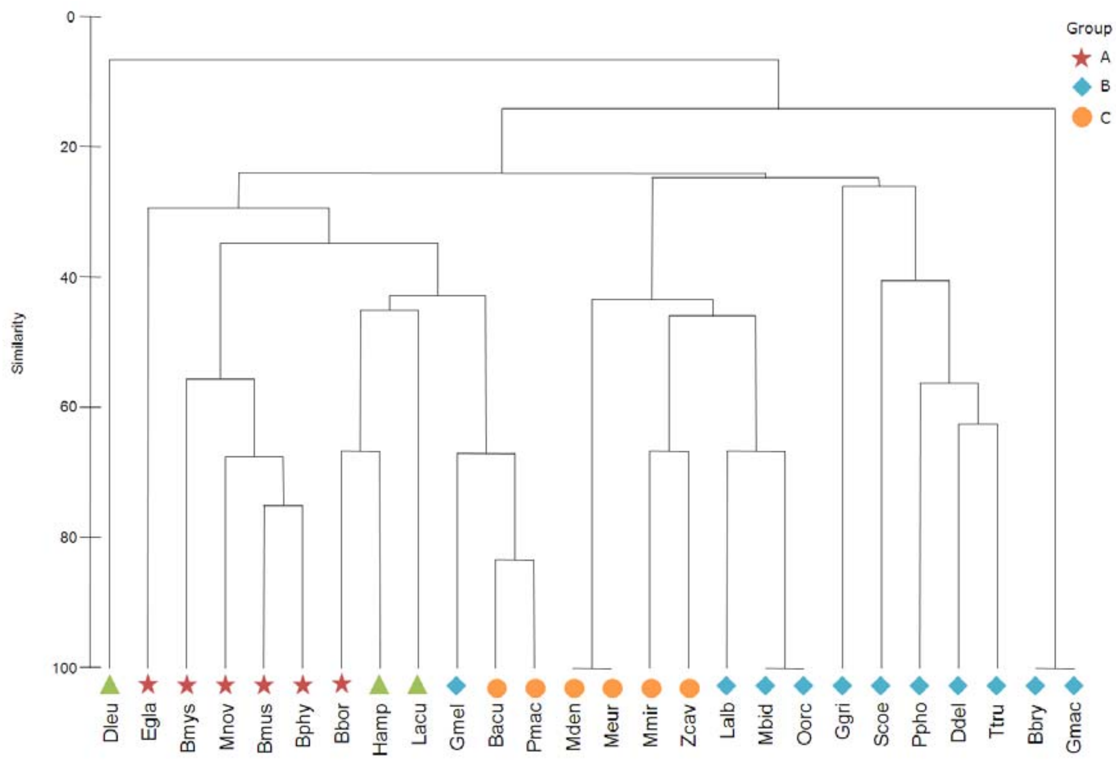

Figure 10. Cluster analysis of species according to human activities, applying the symbol/colour codes as in the correspondence analysis.

3.3. Conservation Instruments

Fifteen international, European, regional and local conservation entities/instruments were reviewed and seven major conservation goals were identified among fourteen of these instruments (Table IV). These refer to the application of restrictions to the direct capture by humans and to some activities that may indirectly affect cetaceans, as well as to promoting the protection of habitats. Many entities and/or agreements have pointed out the species' current conservation status or listed species for which particular goals apply (Appendix III).

3.3.1. International Conservation Instruments

i. International Convention for the Regulation of Whaling (ICRW)

The convention (1946) as well as its Protocol (1946) and the Schedule (according to the 2008 amendments) were reviewed. These set regulations on the taking, killing and treating of all baleen whales and the sperm whale (*Physeter macrocephalus*) by the contracting governments. Such regulations refer to seasons and capture/treatment means and methods which are forbidden, as well as to catch limits, in terms of whale numbers and sizes, for aboriginal subsistence whaling and scientific purposes.

ii. International Union for Conservation of Nature (IUCN)

This is one of the most prominent entities in the conservation frame, which was founded in 1948 as the world's first global environmental organization. Recently, it has established that, for European waters, four species of mysticetes are Critically Endangered (*Eubalaena glacialis*), Endangered (*Balaenoptera borealis* and *B. musculus*) or Nearly Threatened (*B. physalus*), while two are of Least Concern (*B. acutorostrata* and *Megaptera novaeangliae*) (Temple and Terry, 2007). Among odontocetes, two species are Vulnerable (*Phocoena phocoena* and *Physeter macrocephalus*) and two are of Least Concern (*Lagenorhynchus acutus* and *L. albirostris*). All other cetaceans have a Marginal Occurrence in Europe (13) or are Data Deficient (12). For cetaceans, the IUCN recommends that, continuing the IUCN European Mammal Assessment, a comprehensive and integrated conservation strategy should be established, focusing on the individual species as well as on the conservation of sites and the wider environment (Temple and Terry, 2007).

iii. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1979)

This convention was signed in 1979 and Appendices I and II (last updated in 2008), state that all trade in these species shall be in accordance with the provisions of the Articles III and IV, respectively. In this convention, all mysticetes as well as the species *Hyperoodon ampullatus* and *Physeter macrocephalus* are included in Appendix I (which applies stricter regulations on the trade in specimens of these species, by the signatory States), while all other odontocetes are included in Appendix II.

Table IV – Main conservation goals of international, European, regional and United Kingdom legislation and agreements

Main Goals	Legal instruments													
	International			European					Regional			United Kingdom		
	CBD	CITES	ICRW	HSD	EMSD	OSPAR	Bern	CMS	BD	ASC	ACC	UK BAP	WCA	WNIO
Conserve, protect and/or achieve sustainable use of biodiversity	✓		✓	✓		✓	✓	✓	✓		✓	✓		
Conserve and/or protect natural habitats and/or ecosystems	✓			✓	✓	✓	✓	✓						
Protect migratory species	✓		✓				✓	✓						
Protect breeding, rearing and migration				✓			✓			✓			✓	✓
Prohibit and/or regulate deliberate capture and/or keeping and/or killing		✓	✓	✓			✓						✓	✓
Regulate and/or control marine pollution					✓	✓				✓	✓			
Regulate fisheries									✓	✓	✓			

NOTES: CBD – Convention on Biological Diversity; CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora; ICRW – International Convention for the Regulation of Whaling + Protocol + Schedule; HSD – Habitat and Species Directive; EMSD – European Marine Strategy Directive; OSPAR – OSPAR Convention on the Protection of the Marine Environment of the North-East Atlantic + Commission Quality Status Report 2000; Bern – Bern Convention; CMS – Convention on Migratory Species; BD – The Bergen Declaration; ASC – ASCOBANS: Agreement on the Conservation of Small Cetaceans of the Baltic, North-East Atlantic, Irish and North Seas; ACC – ACCOBAMS: Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area; UK BAP – U.K. Biodiversity Action Plan ; WCA – Wildlife and Countryside Act; WNIO – The Wildlife (Northern Ireland) Order (1985).

iv. Convention on Biological Diversity (CBD)

This is a United Nations' Multilateral Convention, concluded at Rio de Janeiro on 5 June 1992, with the objectives of pursuing the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. These include the appropriate access to genetic resources and the appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding. This convention applies to all living organisms and ecosystems.

3.3.2. European Conservation Instruments

i. Bern Convention

This is a Council of Europe Convention on the Conservation of European Wildlife and Natural Habitats, signed in Bern in 19.IX.1979. It lists six cetaceans in Appendix III as protected fauna species (*Delphinapterus leucas*, *Feresa attenuata*, *Hyperoodon ampullatus*, *Lagenodelphis hosei*, *Mesoplodon europaeus* and *Peponocephala electra*). For these, any exploitation shall be regulated through closed seasons, temporary or local prohibition of exploitation and regulation of sale and keeping, transport or offering for sale of live and dead wild animals. All other cetaceans are included in Appendix II as strictly protected fauna species, where all forms of deliberate capture, keeping and killing, deliberate disturbance (particularly during the period of breeding and rearing) and possession of an internal trade in these animals and any readily recognisable part or derivative are prohibited.

v. Convention on Migratory Species (CMS or Bonn Convention)

This is the Council Decision 82/461/EEC of 24 June 1982 on the conclusion of the Convention on the Conservation of Migratory Species of Wild Animals. It includes twenty one of the thirty five cetacean species considered in the present study, in Appendices I and/or II, indicating that "the parties shall endeavour to provide immediate protection for these species" and "to conclude agreements covering the conservation and management of these species", respectively. These Appendices were last reviewed in 2006.

vi. European Community Habitats and Species Directive (HSD)

This is the Council Directive 92/43/EEC of 21 May 1992 in which Annex II refers to "animal and plant species of community interest whose conservation requires the designation of special areas of conservation" and Annex IV to "animal and plant species of community interest in need of strict protection". The species *Phocoena phocoena* and *Tursiops truncatus* are included in Annex II and all cetaceans are included in the Annex IV. Therefore, all forms of deliberate capture, killing or disturbance of cetaceans and the keeping, transport and sale/exchange, and offering for sale/exchange of cetacean specimens taken from the wild are prohibited.

ii. OSPAR Convention on the Protection of the Marine Environment of the North-East Atlantic

This convention was signed in 1992 and the OSPAR Commission Quality Status Report (2000) is one of its documents stating the conservation goals for cetaceans. In the 2008 review, the OSPAR List of Threatened and/or Declining Species and Habitats (for the OSPAR Biological Diversity and Ecosystems Strategy) lists the species *Balaena mysticetus*, *Balaenoptera musculus*, *Eubalaena glacialis* and *Phocoena phocoena* as threatened or declining species in the OSPAR area (or in some of its regions), and for these the contracting parties should set priorities for protection. This should be accomplished by "individually and jointly, take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected" as well as "cooperate in adopting programmes and measures for those purposes for the control of the human activities identified by the application of the criteria in Appendix 3" of the OSPAR Convention.

iii. European Marine Strategy Directive (EMSD)

This is the Directive 2008/56/EC of the European Parliament and of the Council, of 17 June 2008, which establishes a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive), and within which Member States shall take the necessary measures to achieve or maintain good environmental status in the marine environment by the year 2020 at the latest. To achieve that, marine strategies shall be developed and implemented to protect, preserve and restore the marine environment, preventing its deterioration, and to prevent and reduce inputs in the marine environment, with a view to phasing out pollution, to ensure that there are no significant impacts on or risks to marine biodiversity, marine ecosystems, human health or legitimate uses of the sea.

3.3.3. Regional Conservation Instruments

i. ASCOBANS

This is the Agreement on the Conservation of Small Cetaceans of the Baltic, North-East Atlantic, Irish and North Seas, signed in 1992, which was last amended in 2003. Its arrangements apply to all odontocetes (except *Physeter macrocephalus*) referring that the contracting parties should cooperate to achieve and maintain a favourable conservation status for these species following the Conservation and Management Plan in this agreement.

ii. ACCOBAMS

This is the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area, signed in 1996. It concerns seventeen cetaceans listed in Annex I as well as all other cetaceans not listed but which may frequent the agreement area accidentally or occasionally. For these, the contracting parties "shall prohibit and take all necessary measures to eliminate any deliberate taking" and "shall co-operate to create and maintain a network of specially protected areas to conserve" them.

iii. Bergen Declaration

This is a Ministerial Declaration of the Fifth International Conference on the Protection of the North Sea, signed in Bergen, Norway 2002. It recognizes the need to manage all human activities that affect the North Sea, in a way that conserves biological diversity and ensures sustainable development. It focuses on establishing an Ecosystem Approach to management; on the conservation, restoration and protection of species and habitats; on achieving sustainable fisheries; on reducing the environmental impact from shipping; on the prevention of eutrophication and of pollution from hazardous substances, from offshore installations and by radioactive substances; on the promotion of renewable energy; on the problems of marine litter and waste management; and on the cooperation in the process of spatial planning in the North Sea.

3.3.4. United Kingdom Conservation Instruments

i. United Kingdom legislation

All cetaceans are included in Schedule 5 of the Wildlife and Countryside Act (WCA) 1981 [as amended in The Wildlife and Countryside Act 1981 (Variation of Schedules) Order 1988 and the Countryside and Rights of Way (CRoW) Act 2000 (in England and Wales)], as well as in the Wildlife (Northern Ireland) Order 1985. According to these two documents, it is an offence (subject to exceptions) to intentionally kill, injure, or take, possess or trade any cetacean, and it is prohibited to interfere with places used for shelter or protection, or intentionally disturb animals occupying such places. The species *Delphinus delphis*, *Phocoena phocoena* and *Tursiops truncatus* are also protected under Schedule 6 of the WCA, which prohibits certain methods of killing, injuring, or taking wild animals.

ii. United Kingdom Biodiversity Action Plan (UK BAP)

This is the U.K. Government's response to the CBD, signed in 1994. In the most recent list (2007), it includes three grouped plans (baleen whales, toothed whales and small dolphins) and an individual action plan for harbour porpoises (*Phocoena phocoena*). In the short term, these aim to maintain the current range and abundance of all included species, while in the long term they aim on increasing baleen whale population ranges, sizes and abundance (if biologically feasible) through optimising conditions enabling this increase; increasing the ranges of small dolphins' populations where appropriate and ensuring that no anthropogenic factors inhibit a return of harbour porpoises to waters that they previously occupied.

As a result of the enforcement of the provisions of these conventions/entities, amongst the North-East Atlantic cetaceans, all species are included in 7 to 11 of the total of 15 instruments. Therefore, all the main conservation goals (Table IV) apply to most of the NEA cetacean species. Nevertheless, these goals appear to be very universal, resulting in the redundancy of many documents (or, at least, parts of them), particularly for those instruments with global application, while, in contrast, regional instruments tend to define more explicit goals and measures.

4. DISCUSSION

Data on the habitat needs of North-East Atlantic cetaceans and on human activities affecting them were reviewed and compiled. These data were independently treated in correspondence and cluster analyses. Both methods, and for both data sets, showed a clear distinction between mysticetes and odontocetes. Concerning habitat needs, odontocetes could not be further discriminated, arguably for scarcity of data. As to the impact of human activities, odontocetes were then differentiated in two groups: beaked and sperm whales, and dolphins. Fifteen conservation instruments were analysed and seven major conservation goals were indentified which apply to all NEA cetacean species. Nevertheless, these were found to be very general and redundant, and their effectiveness may be at risk.

4.1. Habitat Needs and Human Activities

The mysticetes' preference for deep waters does not imply that they dive to such depths and it may be food-related. Most odontocetes, on the contrary, prefer to live in shallower areas (although some are actually able to perform deep dives). The characteristics identified as distinguishing mysticetes from odontocetes (and vice-versa) seem to agree with other descriptions, particularly with respect to migration, reproduction season and group size (Jefferson *et al.*, 1993; Waller *et al.*, 1996; Reeves, 2002; Waring *et al.*, 2009). In addition, many defining characteristics are directly (e.g. prey species and capture methods) or indirectly (e.g. depth and temperature) related to feeding habits and prey availability, as often suggested by other authors (Davis *et al.*, 1998; Cañadas *et al.*, 2002; Forcada, 2009). *Delphinapterus leucas* position in a midline between the two trends may be related to the fact that this species shares several characteristics with both groups, thus displaying a combination of characters, relative to habitat needs, which is intermediate to the combinations exhibited by the species that compose each of the two tendencies.

With regard to human activities, mysticetes were also distinguished from odontocetes (except for *Balaenoptera brydei* and *B. acutorostrata*), indicating that these groups seem to suffer the effects of different activities, probably due to their distinct biology. It is suggested that the smaller size and more opportunistic habits of *B. brydei* and *B. acutorostrata* (Jefferson *et al.*, 1993; Reeves *et al.*, 2002) may be the reason for them being grouped with the odontocetes.

Whaling and noise from shipping activities are mainly affecting mysticetes, while by-catch (in all types of nets) affects mostly the odontocete species, which is supported by previous accounts. Baleen whales were, and still are, the main target of whaling operations, providing large amounts of meat, blubber (for oil) and baleen fibres (Clapham and Baker, 2002; Roman and Palumbi, 2003). On the other hand, they are more likely to be affected by noise from large ships, given their high sensitivity to sound frequencies below 5 kHz (Evans, 2002; Würsig and Richardson, 2002; Evans, 2003). Conversely, odontocetes actively feed on individual prey, which might be a key factor for their high vulnerability to by-catch, particularly in trawl and gillnet fisheries, where they frequently become entangled while trying to feed on the captured fish (Northridge, 2002). Modern fishing nets, made of strong nylon twine instead of natural fibres, are more resistant and transparent (at least to sight but possibly also to echolocation), increasing the rate of cetacean entanglement (Northridge, 2002; Reeves *et al.*, 2002). The impact may also be increased by the odontocetes' relative smaller size (compared to mysticetes), as they cannot easily free themselves from the nets, with many species being caught in fishing operations (Couperus, 1997; Morizura *et al.*, 1999).

Although baleen whales are frequently hit by ships (Laist, 2001; IWC, 2008), in the North-East Atlantic (NEA) most accounts registered involve toothed whales and dolphins. This may be related to the small size of great whales' populations in this area, depleted by whaling in the past (Clapham and Baker, 2002; Waring *et al.*, 2009), possibly reducing the probability of encounters with ships. Other possible reason may be that some of the killed animals die beyond the continental shelf, therefore sinking to deeper waters (instead of stranding) and are thus not recorded. Nevertheless, ship collisions may be a significant threat to baleen whales, particularly for very small populations or discrete groups, and there seems to be a higher incidence of ship strikes within or near shipping lanes (Laist, 2001). Suggested measures to reduce such impact include, for example, avoiding or reducing traffic in areas known as whale habitats (particularly of threatened species), implementing speed limits in such areas and introducing whale anti-collision systems (e.g., sonobuoys in shipping lanes) to provide real-time data on whales' positions (Laist, 2001; Evans, 2003).

Five of the six beaked whale species analyzed were included in the group most affected by noise from seismic surveys and military activities. This result agrees with many stranding accounts for these species, where the animals showed noise-related injuries, mostly due to behavioural changes such as fast surfacing leading to decompression sickness (Richardson *et al.*, 1995; Jepson *et al.*, 2003; Gordon *et al.*, 2004; Parsons *et al.*, 2007). It has also been suggested that sperm whales (*Physeter macrocephalus*) might be particularly affected by seismic surveys, because during their long and deep feeding dives, they can be hardly detectable (without appropriate acoustic equipment), hence still being within range or even precisely below the seismic guns, in a very vulnerable position (Lewis *et al.*, 1998).

There have not been many recorded changes in cetacean behaviour due to whale-watching activities, but as the whale-watching vessels target areas with high cetacean abundance they are usually considered as potentially harmful (Parsons *et al.*, 2007).

Even though there might be no records of human activities threatening some of the NEA cetaceans, they are potentially affected by the same activities that impact the species clustered in the same group in terms of habitat needs. Therefore, the pigmy killer whale (*Feresa attenuata*), the Fraser's dolphin (*Lagenodelphis hosei*), the melon-headed whale (*Peponocephala electra*) and the rough-toothed dolphin (*Steno bredanensis*) are likely to be affected by by-catch, ship collisions and whale-watching operations, as with all other species of group 4. A similar interaction is also possible for the narwhal (*Monodon monoceros*) and the Atlantic spotted dolphin (*Stenella frontalis*), as three of the four species of group 3 are affected by these activities. The pigmy and dwarf sperm whales (*Kogia breviceps* and *K. sima* respectively) and the false killer whale (*Pseudorca crassidens*) were placed in the centre of the habitat needs diagram; therefore no conclusions can be reached regarding the human activities affecting them.

Finally, it is of note that these results are highly dependent on the quality and quantity of the collected data, which depends itself on the existing information that could be retrieved in the time available for this study. Therefore, the absences may show a lack of information more than a lack of preference for a certain habitat feature or interaction with a human activity. This should be taken into account through the analysis of the results.

4.2. Conservation Implications

Cetacean protection and conservation has long been an international concern and has received support and significant effort from many local and international organizations and governments. Many factors have contributed to this increasing awareness, namely the fact that cetaceans are considered as having especial cognitive capabilities and are, therefore, very charismatic animals ("cute and cuddly"). Such efforts have resulted in the establishment of international, European, regional and local agreements and directives, such as those reviewed before.

Recently, as a result of these joint efforts, cetacean exploitation has departed from large scale extraction (whaling) towards ecotourism, through the observation of cetaceans in their natural habitat (a non-extractive way) – whale-watching. In 2008, 13 million people participated in whale-watching operations in 119 countries/territories around the world (O'Connor *et al.*, 2009). In Europe, whale-watching exists in 22 countries, with around 830,000 whale-watchers in 2008, meaning a 7% average growth *per annum*. Scotland is in the top 10 whale-watching locations in the world, with 2% of the total global whale-watchers, pairing with Portugal-Mainland and Portugal-Madeira in the top five whale-watching growth countries in Europe. Whale-watching' total expenditure was over $21 million in 2008 in the U.K. (with $18 million from Scotland) as well as in Portugal (where the profits came in similar proportion from the Azores, Madeira and the mainland) (O'Connor *et al.*, 2009).

Clearly, the whale-watching industry has grown significantly, but there has been little concern of its potential impacts on the wild fauna. The International Fund for Animal Welfare (IFAW) has promoted responsible whale-watching in sensitive countries, which, if correctly managed, can be a sustainable alternative to whaling and a valuable source of income. This has been complemented by the efforts to use data collected from whale-watching vessels as useful relevant scientific information to the International Whaling Commission (IWC). As the only worldwide body for the protection of cetaceans, the IWC has focused on scientific, legal, socio-economic and educational aspects of whale-watching, thus contributing to its general sustainability and ensuring the recognition of its economic and educational benefits (O'Connor *et al.*, 2009).

In the IWC 61st Annual Meeting (Madeira, Portugal 2009), whale-watching was addressed and the Commission noted the importance of a careful management of the expanding whale-watching industry so as not to cause negative effects on cetaceans, agreeing to form a Standing Working Group on Whale-watching to prepare a five-year strategic plan for its management[1]. The IWC has been facing divisive positions on many items, of which the most problematic seem to be the Japanese small-type coastal whaling, the special permit whaling and the implementation of sanctuaries[2]. At that meeting, the IWC decided that the Small Working Group on the Future of the IWC should continue to work and intensify efforts to conclude a package or packages of measures by 2010 (IWC 62nd Annual Meeting)[3]. This should be a very important step towards the protection of cetaceans on a global scale.

Moreover, the potential effects of climate change on cetaceans have been referred by some authors (Learmonth *et al.*, 2006; Evans, 2009), but little research has been made on this issue so far. Recently, the IWC showed its concern for climate change' negative impacts on, at least, some cetacean species or populations, particularly "those with small and/or restricted ranges, those already impacted by other human activities and those in environments subject to the most rapid change". A resolution was adopted in this meeting referring to the need of Contracting Governments to expand current international multi-disciplinary efforts and collaborative work with other relevant bodies, to incorporate climate change considerations into existing conservation and management plans and to take urgent action to reduce the rate and extent of climate change[4]. This resolution may constitute the driving force for research in this area.

Despite the above, most current conservation goals and management measures are vague and only concern the direct effects of human activities. Indirect effects, such as those related with noise, contaminants or climate change, can be as severe as the direct ones, given their ecosystem-level consequences. However, these have been largely disregarded due to the lack of information on both cetacean ecology and the secondary effects of many human activities. Increased knowledge on the habitat needs of each species may help in the definition of more explicit and effective conservation goals, leading to the protection of the areas that the animals actually use in their activities. For example, while some species feed in inshore areas, others can only find their prey further offshore; therefore, different

[1] Report of the Conservation Committee. International Whaling Commission (IWC) 61st Annual Meeting, Madeira 2009. IWC/61/Rep5. 13 pp.

[2] Report of the Small Working Group (SWG) on the Future of the International Whaling Commission. International Whaling Commission (IWC) 61st Annual Meeting, Madeira 2009. IWC/61/6. 27 pp.

[3] Consensus resolution on the extension of Small Working Group on the Future of the IWC until the 62nd Annual Meeting of the Commission. International Whaling Commission (IWC) 61st Annual Meeting, Madeira 2009. IWC/61/10rev. 1 pp.

[4] Consensus Resolution on Climate and Other Environmental Changes and Cetaceans (submitted by the USA and Norway). International Whaling Commission (IWC) 61st Annual Meeting, Madeira 2009. IWC/61/16. 2 pp.

conservation goals and management initiatives need to be established for the different species, according to their habitat needs.

Additionally, given the wide-ranging and/or migratory nature of cetaceans, regional restrictions may produce few results, so conservation goals need to be defined and applied on an ocean scale, to attain a real protection of the habitats and, consequently, of the species. The present study was intended to contribute to the increase of information on North-East Atlantic cetaceans' habitat needs and on human activities affecting them, as well as to alert for the need of taking this into account when defining conservation goals.

One of the major difficulties found during this project was the availability and heterogeneity of the information, with most of the studies focusing only on a few factors (either habitat needs or human interactions) and on local populations, lacking broader generalised approaches to these issues. This absence of good and consistent sets of data may have induced too many assumptions about the different species. However, it should be kept in mind that rare species will usually produce fewer recordings and observations; hence, it will always be necessary to make some assumptions for these species. Due to the scarcity of information, five human activities (namely by-catch with Traps (*BcPl*), Entanglements in fishing nets (*FEn*) and noise from Dredging (*ND*), Windfarms (*NWf*) and Acoustic alarms (*NAl*)), for which there was only one record of interaction with cetaceans, were removed from the statistical analysis. As a result, these activities' impacts may have been underestimated, while they may actually pose a threat to cetaceans. For such activities, it is crucial to conduct directed assessments, as soon as possible.

In addition, some crucial conservation organisations do not make freely available the information they publish, such as journal articles, special issues, reports or conference proceedings, and many are not even available in a purchasable digital format. The operative sharing of information and cooperation of conservation bodies is crucial to the creation and implementation of more effective conservation measures and proceedings.

Other difficulty was the large number of anecdotal, uncertain records, from opportunistic observations onboard commercial vessels (such as ferries) or whale-watching boats. The cooperation of researchers in such platforms of opportunity to retrieve cetacean observations with scientific methods in a wide coverage over protracted periods has already started (e.g. Brittany Ferries Wildlife Officer

Programme, The Irish Whale and Dolphin Group Ship Surveys Programme and Whale Watch Azores), but is still developing and in need of support to expand.

As noted before, the amount of data collected in this study was dependent on the time availability to obtain and collate it. As a result, more information is probably available on this subject, which could not be retrieved in this study. Thus, these data could be further complemented with an in-depth, long-term, wide range and cooperative research that could provide more accurate and informative results on cetacean habitat preferences and human interactions. This will inevitably require additional field studies, as well as extended data collation exercises. The further creation of a global database with such information, involving the cooperation among conservation, transportation, fisheries and whale-watching organisations and governments, would be a major contribution to cetacean protection and conservation.

In order to reduce anthropogenic-induced disturbance and mortality in cetaceans (to zero if possible), research is advised on all aspects of cetacean ecology, on the effects of activities such as transportation, fisheries, whale-watching and offshore energy projects (as recommended by the International Whaling Commission[5]), as well as on activities with indirect effects related to noise and contaminants. Particular attention should be given to activities for which there are records of negative influence on cetaceans in different geographic areas, as they can also be impacting North-East Atlantic species, although remaining unnoticeable. Above all, the Precautionary Principle should kept in mind and be applied when taking any decisions and actions.

[5] Report of the Scientific Committee. International Whaling Commission (IWC) 61st Annual Meeting, Madeira 2009. IWC/61/Rep5. 108 pp.

5. CONCLUDING REMARKS

The present project, which analysed cetacean habitat needs and the interaction of human activities with them, has enabled the following conclusions:

- It is possible to define habitat needs for a disparate group of organisms as long as there is sufficient information on the ecology of the species;
- However, the compilation and review of existent literature on this subject is a complex process, due to its dispersion through different means and its presentation in different formats;
- Mysticetes and odontocetes have clearly distinct habitat preferences, which generally relate to their feeding (methods and prey species), typical group size, reproduction seasonality and migratory habits;
- In relation to human activities, cetaceans can be distinguished in three groups: mysticetes, sperm and beaked whales and other odontocetes, the first being particularly affected by noise from shipping and whaling, the second by noise from seismic surveys and military activities and the third from by-catch, ship collisions and whale-watching operations;
- Seven major conservation goals exist for North-East Atlantic cetaceans, including the protection of biodiversity, of habitats, of migratory species and of breeding, rearing and migration behaviours and areas, the prohibition of killing and the regulation of industrial and agricultural contaminants and of fisheries. Despite this, many exceptions are allowed, and some member states continue to pursue their activities regardless the protection of wild animals (e.g. Norwegian and Icelandic whaling);

The present project also produced the following recommendations:

- Despite the general existing conservation goals, particular goals should be defined for groups of cetaceans sharing similar habitat needs and/or affected by similar human activities;
- Specific measures on key issues (such as whaling, for example) still require consolidation and enforcement;
- This type of meta-analyses would benefit from the continuing implementation of long-term, cooperative ecological studies of cetaceans in a multi-population perspective.

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APPENDICES

Appendix I – Species' habitat needs

Appendix II – Human activities influencing cetaceans in the North-East Atlantic

Appendix III – Species' status in International, European, Regional and U.K. legal instruments

Appendix I – Species' habitat needs

Habitat need	Behaviour	Range	Code	Species																																			References
				Bacu	Bbor	Bbry	Bmus	Bmys	Bphy	Ddel	Dleu	Egla	Fatt	Ggri	Gmac	Gmel	Hamp	Kbre	Ksim	Lacu	Lalb	Lhos	Mbid	Mden	Meur	Mmir	Mmon	Mnov	Oorc	Pcra	Pele	Pmac	Ppho	Sbre	Scoe	Sfro	Ttru	Zcav	
Depth	Occurrence	0-10 m	DO1																														✓						(Jefferson *et al.*, 1993; Davis *et al.*, 1998; Griffin, 1999; Hooker *et al.*, 1999; Gregr and Trites, 2001; Cañadas *et al.*, 2002; Notarbartolo di Sciara, 2002; Kaschner, 2004; Rendell *et al.*, 2004; Cañadas *et al.*, 2005; MacLeod *et al.*, 2007; Azzellino *et al.*, 2008; Cañadas and Hammond, 2008; Waring *et al.*, 2009)
		10-200 m	DO2	✓				✓			✓	✓									✓							✓								✓	✓		
		200-1000 m	DO3	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓		✓	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓		
		1000-2000 m	DO4	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	
		2000-4000 m	DO5		✓	✓	✓		✓																				✓			✓							
SST	Occurrence	Polar	TO1				✓	✓			✓					✓	✓				✓						✓		✓			✓							(Jefferson *et al.*, 1993; Davis *et al.*, 1998; Notarbartolo di Sciara, 2002; Kaschner, 2004; MacLeod *et al.*, 2007; Waring *et al.*, 2009)
		Cold Temperate	TO2	✓	✓		✓		✓	✓	✓	✓		✓		✓	✓			✓	✓		✓					✓	✓			✓	✓		✓		✓	✓	
		Subtropical	TO3	✓	✓	✓	✓		✓	✓		✓		✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓	
		Tropical	TO4	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓			✓	✓			✓		✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	
Season	Mating	Winter	SM1		✓	✓	✓	✓	✓		✓	✓		✓														✓		✓		✓							(Evans, 1993; Jefferson *et al.*, 1993; Evans and Raga, 2001; Baird, 2002; Kato, 2002; Olson and Reilly, 2002)
		Spring	SM2	✓	✓			✓			✓	✓			✓	✓	✓	✓									✓		✓		✓	✓				✓	✓		
		Summer	SM3							✓					✓	✓	✓	✓		✓	✓								✓		✓		✓		✓		✓		
		Autumn	SM4							✓										✓	✓												✓						
	Calving	Winter	SC1	✓	✓	✓	✓		✓			✓		✓									✓					✓	✓	✓									
		Spring	SC2	✓				✓			✓	✓		✓			✓	✓	✓				✓									✓	✓			✓	✓		
		Summer	SC3							✓	✓				✓	✓	✓	✓	✓	✓	✓						✓				✓	✓	✓		✓		✓		
		Autumn	SC4							✓					✓														✓										
Movements	Migration	Migratory	MM	✓	✓		✓		✓			✓																✓				✓							(Jonsgård, 1966; Baker, 1978; Christensen *et al.*, 1992; Evans, 1993; Jefferson *et al.*, 1993; Kenney, 2002)
		Non migratory	MNm			✓		✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

(Continues)

Appendix I (continued) – Species' habitat needs

Habitat need	Behaviour	Range	Code	Species																																			References
				Bacu	Bbor	Bbry	Bmus	Bmys	Bphy	Ddel	Dleu	Egla	Fatt	Ggri	Gmac	Gmel	Hamp	Kbre	Ksim	Lacu	Lalb	Lhos	Mbid	Mden	Meur	Mmir	Mmon	Mnov	Oorc	Pcra	Pele	Pmac	Ppho	Sbre	Scoe	Sfro	Ttru	Zcav	
Typical group size	Socializing	1 individuals	AG1	✓		✓	✓	✓				✓						✓	✓				✓	✓					✓									✓	(Baker, 1978; Jefferson *et al.*, 1993; Carwardine, 2000)
		2 individuals	AG2	✓	✓	✓	✓		✓			✓						✓	✓				✓	✓			✓	✓	✓									✓	
		3 individuals	AG3	✓	✓			✓	✓			✓	✓					✓	✓		✓			✓			✓	✓	✓				✓			✓	✓	✓	
		4-10 individuals	AG4		✓				✓			✓	✓	✓				✓	✓		✓			✓			✓		✓	✓		✓	✓	✓		✓	✓	✓	
		11-20 individuals	AG5							✓	✓		✓	✓		✓	✓				✓								✓	✓		✓		✓		✓	✓		
		21-50 individuals	AG6							✓	✓		✓	✓		✓					✓								✓	✓		✓		✓		✓			
		51-100 individuals	AG7							✓	✓					✓																		✓					
		101-500 individuals	AG8							✓	✓									✓		✓									✓			✓	✓				
		501-1000 individuals	AG9							✓	✓									✓		✓																	
		>1000 individuals	AG10							✓	✓					✓						✓																	
Prey species	Feeding	Small zooplankton	PZs		✓			✓				✓																											(Waller *et al.*, 1996; Carwardine, 2000; Reeves *et al.*, 2002; Bannister, 2009)
		Large zooplankton	PZl	✓		✓	✓		✓		✓	✓																✓											
		Small fish	PFs	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓				✓		✓	✓		✓	✓	✓	✓		✓	
		Large fish	PFl								✓						✓			✓	✓		✓				✓		✓			✓	✓				✓		
		Cephalopods	PCp		✓		✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		Crustaceans	PCr				✓				✓			✓		✓	✓	✓	✓		✓	✓					✓				✓		✓					✓	
		Benthic invertebrates	PBi					✓			✓						✓																			✓	✓		
		Higher vertebrates	PHv																										✓										
Feeding	Area	Pelagic	FA1	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		(Reeves *et al.*, 2002; Bannister, 2009)
		Demersal	FA2								✓						✓	✓	✓		✓						✓					✓	✓			✓	✓	✓	
	Capture method	Filtering	FCm1	✓	✓	✓	✓	✓	✓			✓																✓											(Jefferson *et al.*, 1993; Reeves *et al.*, 2002)
		Hunting	FCm2							✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

Appendix II – Human activities influencing cetaceans in the North-East Atlantic

NEA Human activities		Code	Species																										Sum of species affected	References
			Bacu	Bbor	Bbry	Bmus	Bmys	Bphy	Ddel	Dleu	Egla	Ggri	Gmac	Gmel	Hamp	Lacu	Lalb	Mbid	Mden	Meur	Mmir	Mnov	Oorc	Pmac	Ppho	Scoe	Ttru	Zcav		
Noise	Ships/boats	NSh				✓	✓	✓		✓												✓			✓		✓		7	(Stone, 1998; Parsons *et al.*, 2000a; Parsons *et al.*, 2000b; Parsons *et al.*, 2007)
	Windfarms	NWf																							✓				1	
	Dredging	ND					✓																						1	
	Seismic surveys	NSs	✓	✓		✓		✓	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	20	
	Military activities	NMa	✓											✓	✓						✓			✓	✓			✓	7	
	Acoustic alarms	NAl																							✓				1	
By-catch	Gillnets/Driftnets	BcG							✓					✓								✓			✓	✓	✓		6	(Northridge, 1991; Fertl, 1997; Tregenza *et al.*, 1997; Parsons *et al.*, 2000b; Parsons *et al.*, 2007; Rogan and Mackey, 2007)
	Trawls	BcT							✓							✓	✓								✓		✓		5	
	Purse seine	BcPs							✓					✓															2	
	Tuna fishery	BcTf	✓						✓			✓		✓		✓								✓		✓	✓		8	
	Traps	BcPl												✓															1	
Ship collisions		Sc	✓		✓			✓	✓				✓	✓			✓	✓					✓	✓	✓	✓	✓	✓	14	(Laist, 2001; Parsons *et al.*, 2007)
Whaling		W	✓	✓		✓	✓	✓			✓			✓	✓	✓						✓		✓					11	(Parsons *et al.*, 2000b; Olson and Reilly, 2002)
Whale-watching		Ww										✓												✓			✓		3	(Magalhães *et al.*, 2002; Visser *et al.*, 2006)
Fisheries entanglements		FEn														✓													1	(Cipriano, 2002)
Contaminants	Trace elements	CTe	✓					✓	✓	✓		✓		✓		✓	✓	✓	✓				✓	✓	✓	✓	✓		13	(Law et al., 1992; Law et al., 1996; Law et al., 1997; Tilbury et al., 1997; Holsbeek et al., 1999; Law et al., 1999; Parsons et al., 2000b; Aguilar et al., 2002; Hobbs et al., 2003; Parsons et al., 2007)
	PAHs	CPah								✓														✓	✓				3	
	Organochlorines	CO	✓						✓	✓		✓		✓		✓		✓	✓				✓	✓	✓	✓	✓		14	
	Butyltins	CBu	✓					✓	✓			✓		✓	✓	✓	✓	✓	✓						✓	✓	✓		13	

Appendix III – Species status in International, European, Regional and United Kingdom legal instruments

Species	Legal instruments												Sum of Instruments
	International			European				Regional		United Kingdom			
	IUCN Red List Status WW (EU)	CITES Appendix	ICRW	HSD Annex	OSPAR	Bern Appendix	CMS Appendix	ASCOBANS	ACCOBAMS	UK BAP Action plan	WCA Schedule	WNIO Schedule	
Balaena mysticetus	LC (NA)	I	✓	IV	✓	II	I				5	5	9
Balaenoptera acutorostrata	LC (LC)	I	✓	IV		II			✓	①	5	5	9
Balaenoptera borealis	EN (EN)	I	✓	IV		II	I/II		✓	①	5	5	10
Balaenoptera brydei	DD (NA)	I	✓	IV		II	II				5	5	8
Balaenoptera physalus	EN (NT)	I	✓	IV		II	I/II		✓	①	5	5	10
Balaenoptera musculus	VU (EN)	I	✓	IV	✓	II	I			①	5	5	10
Delphinapterus leucas	NT (NA)	II		IV		III	II	✓			5	5	8
Delphinus delphis	LC (DD)	II		IV		II	I/II	✓	✓	③	5/6	5	10
Eubalaena glacialis	E (CR)	I	✓	IV	✓	II	I		✓	①	5	5	11
Feresa attenuata	DD (NA)	II		IV		III		✓			5	5	7
Globicephala macrorhynchus	DD (NA)	II		IV		II		✓			5	5	7
Globicephala melas	DD (DD)	II		IV		II	II	✓	✓	②	5	5	10
Grampus griseus	LC (DD)	II		IV		II	II	✓	✓	③	5	5	10
Hyperoodon ampullatus	DD (DD)	I		IV		III	II	✓		②	5	5	9
Kogia breviceps	DD (NA)	II		IV		II		✓			5	5	7
Kogia sima	DD (NA)	II		IV		II		✓	✓		5	5	8
Lagenodelphis hosei	LC (NA)	II		IV		III	II	✓			5	5	8
Lagenorhynchus acutus	LC (LC)	II		IV		II	II	✓		③	5	5	9
Lagenorhynchus albirostris	LC (LC)	II		IV		II	II	✓		③	5	5	9
Megaptera novaeangliae	LC (LC)	I	✓	IV		II	I			①	5	5	9

(Continues)

Appendix III (continued) – Species status in International, European, Regional and United Kingdom legal instruments

Species	Legal instruments												Sum of Instruments
	International			European				Regional		United Kingdom			
	IUCN Red List Status WW (EU)	CITES Appendix	ICRW	HSD Annex	OSPAR	Bern Appendix	CMS Appendix	ASCOBANS	ACCOBAMS	UK BAP Action plan	WCA Schedule	WNIO Schedule	
Mesoplodon bidens	DD (DD)	II		IV		II		✓		②	5	5	8
Mesoplodon densirostris	DD (DD)	II		IV		II		✓	✓		5	5	8
Mesoplodon europaeus	DD (DD)	II		IV		III		✓			5	5	7
Mesoplodon mirus	DD (DD)	II		IV		II		✓		②	5	5	8
Monodon monoceros	NT (NA)	II		IV		II	II	✓			5	5	8
Orcinus orca	DD (DD)	II		IV		II	II	✓	✓	②	5	5	10
Peponocephala electra	LC (NA)	II		IV		III		✓			5	5	7
Phocoena phocoena	LC (VU)	II		II/IV	✓	II	II	✓	✓	④	5/6	5	11
Physeter macrocephalus	VU (VU)	I	✓	IV		II	I/II		✓	②	5	5	10
Pseudorca crassidens	DD (NA)	II		IV		II		✓	✓		5	5	8
Stenella coeruleoalba	LC (DD)	II		IV		II	II	✓	✓	③	5	5	10
Stenella frontalis	DD (NA)	II		IV		II		✓			5	5	7
Steno bredanensis	LC (NA)	II		IV		II		✓	✓		5	5	8
Tursiops truncatus	LC (DD)	II		II/IV		II	II	✓	✓	③	5/6	5	10
Ziphius cavirostris	LC (DD)	II		IV		II		✓	✓	②	5	5	9

NOTES: IUCN Red List – WW – World Wide (2008 update); EU – European Union (2007 update). Extinct (EX); Extinct In The Wild (EW); Critically Endangered (CR); Endangered (EN); Vulnerable (VU); Near Threatened (NT); Least Concern (LC); Data Deficient (DD); Not Evaluated (NE); (NA) Not Applicable/Marginal Occurrence in Europe; CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora: Appendices I and II (2008); ICRW – International Convention for the Regulation of Whaling + Protocol + Schedule (2008 amendment); HSD – Habitat and Species Directive: Annexes II and IV; OSPAR – OSPAR List of Threatened and/or Declining Species and Habitats (2008); Bern – Bern Convention: Appendices II and Appendix III; CMS – Convention on Migratory Species: Appendices I and II; ASCOBANS – Agreement on the Conservation of Small Cetaceans of the Baltic, North-East Atlantic, Irish and North Seas; ACCOBAMS – Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area; UK BAP – U.K. Biodiversity Action Plan: List 2007 – ① Grouped plan for baleen whales, ② Grouped plan for toothed whales, ③ Grouped plan for small dolphins, ④ Action plan for harbour porpoise (*Phocoena phocoena*); WCA – Wildlife and Countryside Act 1981: Schedules 5 and 6; WNIO – The Wildlife (Northern Ireland) Order 1985: Schedule 5.